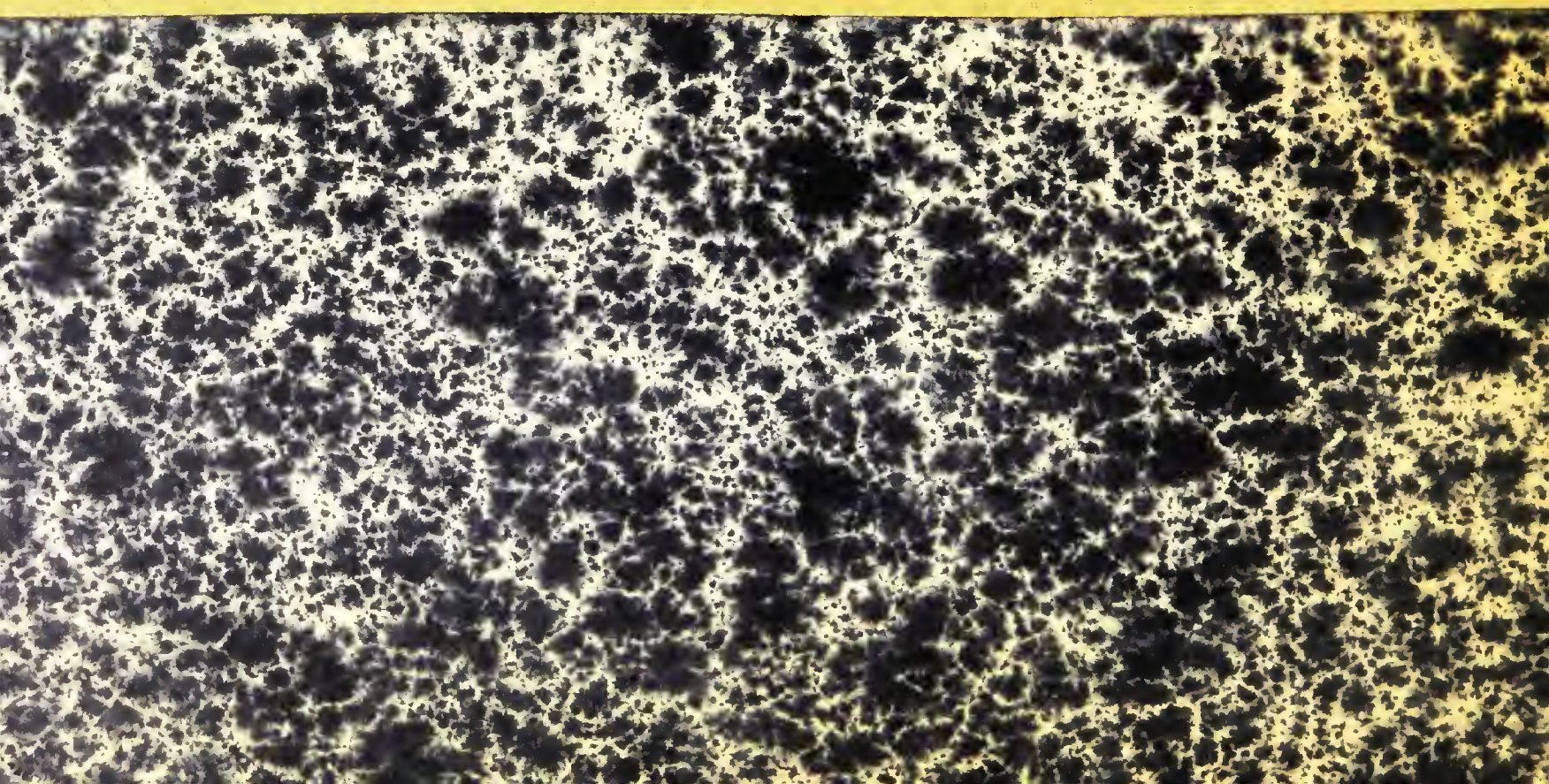

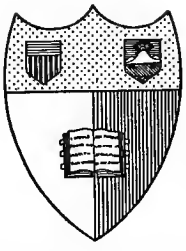

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BY

WALCOT GIBSON, D.Sc.

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CHAPTER I.

General Description.

Introduction.

The area shown in the sketch-map (Plate 1) of the concealed part of the Yorkshire and Nottinghamshire Coalfield proved by the borings and shafts described in this memoir, amounts to about 1,200 square miles. It can be regarded as consisting of a northern portion—now generally known as the East Yorkshire Coalfield—situated between Doncaster and the river Ouse; and of a southern portion which extends over nearly the whole of the county of Nottingham. The districts in which boring explorations are most active are located chiefly in the trench-like valley of the Trent from Nottingham—where this important waterway becomes navigable—to its confluence with the Humber. Development by shaft-sinking as well as by boring is chiefly taking place in areas bordering the Don between Goole and Doncaster, the Aire east of Knottingley, and the Ouse below Selby. A large area, as yet almost untouched, lies west of the Trent between Newark and Gainsborough; south of the Trent the extension of the coalfield has been proved in several borings.

The chief centres of population are Nottingham, Newark, Mansfield, Retford, Gainsborough, Doncaster and Selby; and as the result of colliery development the population is rapidly increasing, not only by the influx of inhabitants into the older towns but by the creation of towns and villages near each newly opened pit.

The surface of the Nottinghamshire, Derbyshire, and Yorkshire coalfields rises in the east up to a bold escarpment of Permian limestone, which extends in unbroken continuity from the western outskirts of Nottingham city across the coalfields northward into the county of Durham. For many years it was thought that the coal-seams either did not continue east under the Permian limestone or that the general eastward dip of the strata would carry them to a depth too great for profitable mining. So late, indeed, as the middle of last century coal-mining was restricted to the region lying west of the Permian limestone. In 1854, the Duke of Newcastle commenced to sink two pits at Shireoaks, and early in 1859 the valuable Top Hard Coal was cut at a depth of 1,530 feet and proved to be 3 feet 10 inches in thickness. Development southward followed rapidly; and at the present day most of the chief collieries of Nottinghamshire are situated within the outcrop of the Permian limestone. In following the Top Hard Coal to the east, its eastward dip was found gradually to diminish. There seemed therefore every prospect of finding the seam at workable depths still further east beneath the red Triassic rocks which rest upon the Permian formation in this direction. Successful attempts were first made near Nottingham, thence to the north and to the east, thus gradually leading up to the most recent explorations.

Shape of the Ground.

In the southern region between Retford and Nottingham the general structure of the country takes the form of a low plateau dissected by the Trent and its tributaries. The ground rises a few feet above the 600-foot contour-line and thence declines gradually down to the alluvial flats bordering the Trent. North of Bawtry the ground slopes to the north and finally merges into an alluvial plain lying between 10-30 feet above sea-level. A few low hills, like those near Heck, and more conspicuously illustrated by the Isle of Axholme, rise here and there above the general level surface.

Geological Sketch.

The visible part of the coalfield only constitutes the western edge of a basin, the remainder of which, with the exception of small parts of the northern and southern margins, is concealed beneath successive sheets of newer formations. Except for a limited distance in the south-west the margins of this concealed part have not been proved in any of the sinkings or borings; all, with two exceptions (Ruddington and Kelham), having failed to reach the base of the Coal Measures, which belong to the highest division of the Carboniferous System.

The following is a summary of the solid formations and their main divisions which either enter into the composition of the concealed coalfield (A) or form its cover (B):

Table of Formations.

Non-coal-bearing (B).		Rhætic	Black and grey shales with nodular limestones.
	Triassic	Keuper Marl and Sandstones.	Red and variegated marls with thin flaggy sandstones and marl.
		Bunter Pebble Beds and Sandstones.	Soft sandstones and sandrock with pebbles.
	Permian	Upper Permian Marl ...	Red marls.
		Upper Permian Limestone	Magnesian limestone.
		Middle Permian Marl ...	Red marls.
		Lower Permian Limestone and Basement Beds.	Magnesian limestone.
Coal-bearing (A).	Carboniferous.	Upper Coal Measures ...	Red and grey sandstones and red marls.
		Middle Coal Measures ...	Grey shales and sandstones with numerous coal-seams.
		Lower Coal Measures ...	Grey sandstones and shales with a few coal-seams.
		Millstone Grit	Massive sandstones and shales.

Carboniferous.—A thickness of about 4,000 feet of Coal Measures has been proved in the concealed area but the greatest thickness proved in a single shaft or boring amounts to 2,317 feet (Maltby Colliery). The highest measures have been pierced in two borings (Oxton, Thurgarton), the lowest only in borings at Ruddington and Kelham. All the other borings and shafts end in Middle Coal Measures.

The Lower and Middle Coal Measures consist of alternations of grey shales, sandstones, and coal-seams. In the Lower Coal Measures thick bedded sandstones predominate; in the Middle Coal Measures the sandstones are generally of a flaggy character. Though some workable coals occur in the Lower Coal Measures, the Middle Coal Measures contain the chief seams, one of which named the Top Hard Coal in Nottinghamshire and Barnsley Coal in Yorkshire, is, from its superior quality, the seam invariably sought after. The Upper Coal Measures do not possess workable seams and are composed chiefly of red sandstones and red marls.

The various beds were originally laid down in approximately level sheets and extended not only over the whole district but far beyond it. But whatever may have been their original extension the present outline of the coalfield has been determined by several and distinct operations taking place at different periods. Chief among these are the earth-movements which elevated the strata and at the same time buckled them up into a series of ridges (anticlines) and intervening depressions (synclines).

The rise of the measures towards the southern, western, and northern margins records the effect of this folding; while the fretted edges of the Carboniferous rocks around the margins and the planed down surface of the Coal Measures over the central part of the syncline resulted from denudation. Since the folding, tilting and denudation of the Carboniferous rocks was completed before the commencement of the Permian period the covering Mesozoic formations rest unconformably on their eroded and upturned edges.

As a result of the elevation the Carboniferous rocks were extensively pared down by the denudation, the erosion being most active over the ridges; while in the depressions the Coal Measures, which escaped destruction, form the present coalfield.

Permian.—On the nearly plane surface produced by the erosion of the Carboniferous rocks the Permian and Triassic deposits, which now cover the Coal Measures, were afterwards overspread.

The earliest of these newer deposits was the Magnesian Limestone, a formation of which the prominent member differs wholly in character and was laid down under very different conditions from the underlying Coal Measures. Where it reaches its full development in the district, the Magnesian Limestone consists of two beds of limestone separated and overlain by red marl. The greatest thickness of the formation proved in any one boring amounts to 622 feet (Thorne). The limestone contains much magnesium carbonate and with it were formed contemporaneously masses and beds of gypsum and anhydrite. In addition to these minerals the red marls contain rock salt in beds sometimes as much as 20 feet in thickness. Such minerals indicate that the Permian waters occupied a land-locked basin such as the present Caspian Sea, and unlike the estuaries and lagoons in which the sediments of the Coal Measures accumulated.

Trias.—In persistence and superficial extent the Trias is the predominant rock system of the district, and overspreads more

than two-thirds of the coalfield. The formation reaches a thickness of nearly 2,000 feet and is separable into two major divisions of different composition. The Lower or Bunter division consists mainly of sands, soft sandstones and pebbly beds; and the Upper or Keuper, mainly of red clays or marls with some subordinate sandy beds which are thickest and most persistently developed in the lower part. In Nottinghamshire, the sandstones in the lower part of the Keuper, sometimes called 'Waterstones,' are fine-textured even-bedded rocks with an impersistent hard conglomerate from a few inches to 2 feet in thickness at the base, overlain by greyish-green shaly clay, 15 to 20 feet thick, passing up into red shaly clays, loams, and sandstones of the usual type. In Yorkshire these characteristic basal beds are absent and the Keuper Waterstones cease to be recognisable in borings, having either merged upwards into the Keuper Marl, or else the sandstones have assumed the Bunter type and so become inseparable from this division.

Towards their summit the red Keuper Marls pass up into pale green or greyish shales (Tea-green Marl) which generally form an outcrop clearly defined by the pale colour of the soil. They are also recognisable in borings at Owthorpe, South Scarle, and Scunthorpe.

Rhætic.—Above the Keuper, a thin series of deposits, termed Rhætic, consisting of black shales in the lower part, overlain by grey shales with nodules and layers of thin-bedded limestones, are usually classed with the Trias. The black shales bear some resemblance to the carbonaceous shales of the Coal Measures but contain fossils which are quite distinct from any Carboniferous forms.

The borings at Owthorpe and South Scarle enter the Rhætic beneath a few feet of Liassic shales and limestone; elsewhere the concealed coalfield has so far not been proved further east than the outcrop of the Rhætic.

Superficial Deposits.—The Rhætic formation doubtless at one time overspread much of the area to the west of its present outcrop; but all traces of its former extension or of that of any newer Mesozoic strata have been removed by prolonged erosion. The superficial deposits all belong to comparatively recent periods. They occur in patches, and so far as is known attain importance only over the region north of Bawtry.

Of these superficial deposits the oldest are the Glacial drifts which, locally, as near Doncaster, reach a thickness of nearly 100 feet (Bentley Colliery); but are comparatively thin elsewhere. Their composition varies from a stiff clay filled with far-travelled stones (Balby) to a loose running sand containing much water and presenting considerable engineering difficulties in sinking shafts through it.

The most recent deposits of all are the gravels and alluvia associated with the existing valley-systems, and the warp clays and sands which cover the plains in south Yorkshire.

CHAPTER II.

THE CARBONIFEROUS ROCKS.

The rocks of the Carboniferous System as represented in the centre of England are usually divided into the following groups:—

Upper Carboniferous	Coal Measure Series.
	Millstone Grit Series.
Lower Carboniferous	Limestone Shales (Yoredale rocks).
	Carboniferous Limestone.

Both the Upper and Lower Carboniferous rocks are well developed in the exposed coalfield and along its western margin; but in the concealed coalfield none of the borings have reached rocks older than the Limestone Shales, and indeed, with two exceptions (Ruddington, p. 52, Kelham, p. 57), they have not passed through the base of the Lower Coal Measures.

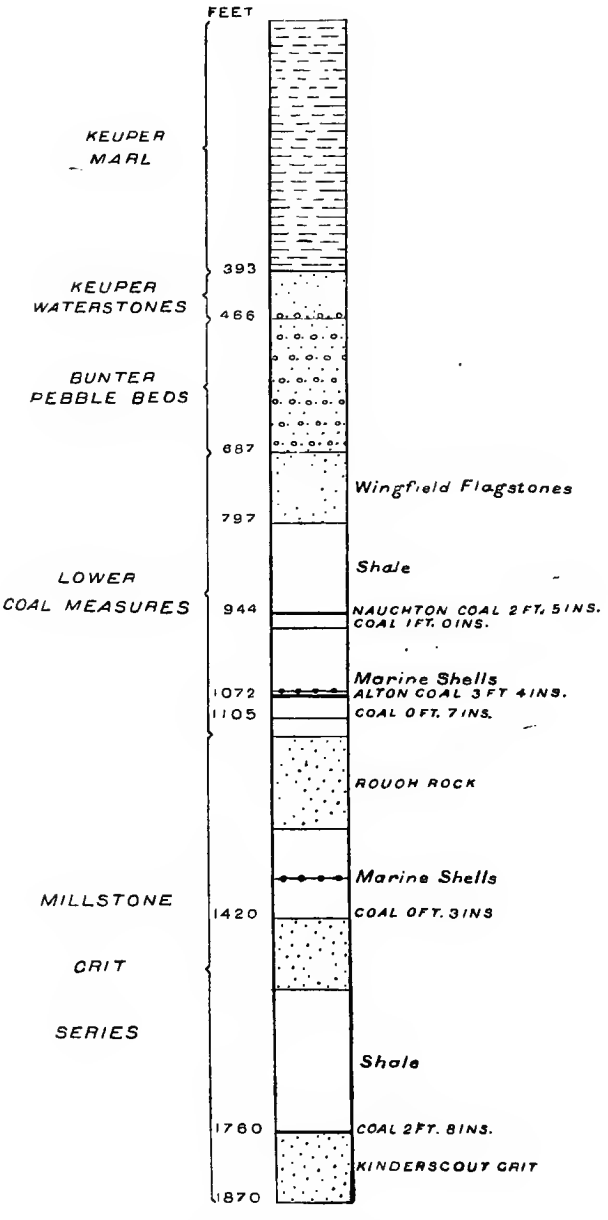
In the Soar Valley, across the southern margin of the map (Plate I.), two borings[1] near Hathern, six miles south-west of Ruddington, passed from Trias into the Pre-Cambrian "Charnwood Forest Rocks"; and in the same valley, south of Quorndon the Pre-Cambrian granitic rocks of Mount Sorrel come to the surface from beneath a mantle of Keuper Marl. This would leave only a narrow strip for the buried outcrop of the Lower Carboniferous rocks between the Soar Valley and Ruddington. From the information obtained in the boring at Thurgarton (p. 56) and elsewhere, and from the present knowledge of the underground structure of the area, it is very improbable that they will ever be reached by any boring west of the Trent. Further, it can be reasonably inferred that the Permian and Triassic rocks will be found everywhere resting on the Coal Measures and over the greater part of the area on the Middle Coal Measures which would place the Lower Carboniferous rocks below a depth of 4,000 feet.

Millstone Grit Series.

This series, as previously mentioned, has been proved at Ruddington (Fig. 1 and p. 52) in the extreme south-west and recently at Kelham (p. 57). Along the western margin of the visible coalfield the thickness of the sub-division varies between 1,000-1,200 feet, and consists of several thick beds of coarse-grained usually massive sandstones separated by thick bands of shale. As no workable coals have been found below the highest bed of sandstone, it is familiarily known to the miner as the Farewell Rock, but it is more generally termed the Rough Rock or First Millstone Grit. The sandstones below the Rough Rock have received different names of which the Kinderscout or Fourth Grit, lying towards the base of the series, is the best known. In the Ruddington Boring the First Grit proved to be 164 feet in thickness, and

[1] 'The Geology of the Leicestershire and South Derbyshire Coalfield,' *Mem. Geol. Surv.*, 1907, pp. 358–359.

FIG. 1.—*The Ruddington Boring.*



Scale, *One Inch = 300 Ft.*

beneath this the boring was continued in the series down to 109 feet in Kinderscout Grit. The total thickness of the Millstone Grits above the Kinderscout Grit at Ruddington amounts to 739 feet as compared with 600 feet in the Derwent Valley to the north-west. The Millstone Grits, therefore, instead of dwindling to the south-east would appear to increase in thickness in this direction, so that it is reasonable to postulate their further extension to the south-east of Ruddington.

From the evidence obtained in the boring at Kelham, near Newark, it appears that the Millstone Grits rise up and abut against the Permian rocks a few miles east of the Trent (p. 46 and Fig. No. 3, p. 45).

Coal Measures.

The Coal Measures reach a thickness of over 5,000 feet. In this long column of strata the workable coals are most abundant and regular in the middle, less frequent and more variable in the lower, and absent in the upper part. The following classification, which is based on the occurrence of the workable coals, is the one usually adopted in the district:—

Upper Coal Measures (500 feet).	Red sandstones and marls (Keele Group). Grey sandstones with thin coals (Newcastle-under-Lyme, Group). Red marls and green grits (Etruria Marl Group).
Middle Coal Measures (2,300–3,300 feet).	Grey shales and sandstones with the chief workable seams. Base, the Silkstone or Blackshale Coal.
Lower Coal Measures (1,200–1,600 feet).	Grey sandstones and shales with some workable seams. Base, the Rough Rock or First Millstone Grit.

For the present purpose a more suitable classification has not been devised, but it may be useful to state briefly what has been accomplished by taking the life-history of the period as shown by the fossils, which should, if the palæontological material were sufficient, afford a more definite basis of classification which would be applicable not only to the present area but to all European coalfields.

The latest schemes of classification are those based on the vertical distribution of the fossil plants. In the Yorkshire Coalfield, Dr. Kidston on the evidence of the plants, has taken the horizon of the Silkstone Coal as the dividing line between the Lower Coal Measures below this coal and the Middle Coal Measures between it and the base of the red measures seen at Conisborough (equivalent to the red measures at the top of the Coal Measures at Maltby, p. 63). More recently he has proposed the term 'Lanarkian Series' to include the Millstone Grits and Lower Coal Measures, and the term 'Westphalian Series' for the Middle Coal Measures.[1] Above the 'Westphalian' Coal Measures and the equivalent Middle Coal Measures of other British coalfields, Dr. Kidston recognises a 'Transition Series' to which he gives the name of the 'Staffordian Series.' This

[1] 'On the Divisions and Correlation of the Upper Portion of the Coal Measures, with special reference to their Development in the Midland Counties of England.' *Quart. Journ. Geol. Soc.*, vol. lxi, 1905, p. 308.

includes the Etruria Marl and Newcastle-under-Lyme groups met with in the boring at Thurgarton, while the sandstones and marls of the Keele Group are referred by Dr. Kidston to the Upper Coal Measures.

By some continental geologists the Keele Group is included in the Westphalian division and it is considered that the existence of any true Upper Coal Measures (Stephanian) in the sense in which the term is applied in France, Belgium and Germany has not been proved in Britain, and Dr. E. A. N. Arber has recently expressed the same opinion.[1] It therefore appears desirable to adhere to the classification given in the table above since it is the one adopted locally and is of practical utility. It should be kept in mind, however, that above the highest (Keele) group a great thickness of Upper Coal Measures (Stephanian) occurs on the continent, and that, so far, any indication of their being present on the east side of the Pennines is not generally accepted.

As regards the accessibility of the coals, the boring at Kelham indicates that the lower seams of the Middle Coal Measures are well within the 4,000 feet limit of working in Nottinghamshire. In South Yorkshire, from the evidence of the Thorne Boring, it is reasonable to infer that they will seldom exceed this depth; while the Top Hard Coal in Nottinghamshire and Barnsley Seam in Yorkshire should be met with under 3,000 feet.

The absence of the Upper Coal Measures at Kelham shows that these barren measures do not occur over so wide an area as might have been supposed from their considerable thickness in the Thurgarton Boring. The large basin of the concealed Yorkshire and Nottinghamshire Coalfield differs in this respect from the hidden basin between the Warwickshire and South Staffordshire coalfields and from that lying under the Trias between the two Staffordshire coalfields and those of Shropshire and North Wales. In both of these basins the Trias rests on the barren Upper Coal Measures which are nearly 2,000 feet in thickness, so that where the thickness of the Trias amounts to 1,000 feet the workable coals beneath them lie over 3,000 feet in depth in many places.

Lower Coal Measures.

The Lower Coal Measures are imperfectly known in the concealed coalfield. In the north-west they have been proved in shafts sunk through the Magnesian Limestone; in the south-east at Kelham; and in the south-west by the boring at Ruddington. Elsewhere a considerable thickness of Middle Coal Measures intervenes between the Lower Coal Measures and the Mesozoic formations. The areas proved lie so far apart that to understand the significance of the sequence proved by the borings and shafts it will be necessary to state what is known about the Lower Coal Measures in the exposed coalfield.

The following table gives the names borne by the coals and sandstones in different parts of the field with the average thickness in feet of the main members. The succession for Yorkshire is taken from 'The Geology of the Yorkshire Coalfield' (*Mem*

[1] 'The Natural History of Coal,' 1911, p. 26.

Geol. Surv, 1878, p. 76), the higher figures in the right-hand column giving the average thicknesses in South Yorkshire, and the lower figures the average thicknesses in North Yorkshire.

Thickness in Feet.	Derbyshire.	S. Yorkshire.	N. Yorkshire.	Thickness in Feet.
110	Measures ...	... ...	... ...	210–170
	Mickley coals ...	*Whinmoor coals*...	*Beeston coals.*	
290	Measures with Kilburn Rock.	Measures with irregular sandstones.	Measures with Oakenshaw Rock.	
		Penistone Flags...	... ...	
	Kilburn Coal ...	*Grenoside Sandstone Coal.*	*Crow Coal* ...	
		Grenoside sandstone.	Measures with Low Moor Ironstone.	630–330
440	Measures with Wingfield Flagstones.	... ...	*Black Bed Coal* ...	
		Measures ...	Measures with Thick Stone.	
		Underclay and Thin Coal.	*Better Bed Coal.*	
		Elland Flagstones		
130	Measures with thin coals.	Measures with irregular sandstones and thin coals.		540–360
	Alton Coal ...	*Gannister, Halifax or Hard Bed Coal.*		
		Measures		
		Clay or Middle Bed Coal		150–30
60–270	Measures with sandstones and thin coals.	Measures with Middle Rock		
		Coking or Soft Bed Coal.		
		Crawshaw Sandstone and Soft Bed Flags or equivalent measures.		120–50
		Measures...		
	'*Belper Lawn*' *Coal.*	Thin Coal and Underclay.		

From a thickness of 1,068 feet in the shafts at Denby Colliery near the southern margin of the Derbyshire Coalfield the measures expand to about 1,650 feet in South Yorkshire and then diminish to 1,040 feet in the northern part of the coalfield. The expansion takes place chiefly in the upper part of the sequence and is due to the incoming of sandstones and sandy shales which attain their maximum development around Sheffield. In comparison with the main sandstones of the Millstone Grits, those in the Lower Coal Measures are of finer grain, more felspathic, and very liable to rapid changes in composition. Thus the sandstones of the Wingfield Flagstone group frequently become split up into several beds by the intercalation of shale, while in some localities the group consists chiefly of sandstone. Occasionally, as at Wharncliffe Edge, the sandstones are indistinguishable from the Millstone Grits.

Of the coals, two only, which occur near the bottom of the group, can be recognised with any certainty over the entire coalfield. A

thin coal with fireclay in Yorkshire and North Derbyshire rests either immediately on the Rough Rock or is separated from it by only a few feet of shale. It attains a thickness of 3 to 4 feet in the Derwent Valley where it has been worked at several localities south of Ambergate. It is represented at Ruddington by the coal 7 inches thick occurring at the depth of 1,105 feet (fig. 1, p. 6). The next coal, which is universally represented but is seldom of a workable thickness, occurs between 59 feet (Ruddington) and 270 feet (North Derbyshire and South Yorkshire) above the Rough Rock. This is the Alton Coal of Derbyshire and the Gannister (Halifax or Hard Bed) Coal of Yorkshire. In Derbyshire it is a coking coal of variable quality and most frequently too thin to be worked: in Yorkshire, to the north of Leeds it has been largely gotten, chiefly as an engine coal. The floor is usually the hard siliceous rock termed gannister. The seams above, though locally of considerable importance, vary greatly in thickness and quality. In Yorkshire the Better Bed Coal, from its great purity and suitability for iron-smelting, has been extensively worked to the south-east of Huddersfield. No equivalent seam has been recognised in Derbyshire but higher in the sequence the Kilburn Coal (4-5 feet thick) here furnishes a superior house coal. It appears to be only a thin seam at Wollaton Colliery, west of Nottingham, and has not been proved to the south where the Ruddington Boring enters the Lower Coal Measures below this horizon. Around Leeds, Garforth, Marston and Peckfield, the Beeston Coal, which is formed by the union of two coals, occasionally reaches a thickness of more than eight feet, and forms one of the most valuable seams in the northern part of the coalfield. There is no seam corresponding to it in value in Derbyshire where, practically, the Kilburn Coal constitutes the only important seam, the Alton Coal being too variable in thickness or too sulphury to be of much account. For this reason no shafts have been sunk to the Lower Coal Measures south of the Trent though these are known from the Ruddington and Kelham borings to be at shallow depths. Even to the north-east of Leeds where they are more productive, it has not been thought worth while to sink to them to any big depth. It is therefore important to ascertain by what means, if any, the Lower Coal Measures can be distinguished since they may be found in borings put down in search of the seams in the Middle Coal Measures as actually has been the case at Kelham (p. 58), and possibly at Clipston (p. 51), and Selby (p. 68). Lithologically the Lower and Middle Coal Measures are on the whole very similar, and as will now be shown the palæontological differences, if any, are extremely slight.

Palæontology of the Lower Coal Measures.—A fauna distinctive of one horizon and thus enabling it to be identified with certainty over the coalfield occurs in the roof shales of the Alton or Gannister Coal. The best exposure of this band is in the Bullbridge Brick pits at Ambergate, where the lower two feet at the base of about 20 feet of shale contain *Lingula mytiloides* J. Sow.; *Posidoniella minor* (Brown); *Pterinopecten papyraceus* (J. Sow.); *Gastrioceras carbonarium* (von Buch); *G. listeri* (Mart.); *Glyphioceras bilingue*

(Salt.); several small gasteropods and the fish-spine *Listracanthus*. Though not always so prolific as this the shales invariably contain *Lingula* and *Pterinopecten* associated generally with one or more species of goniatites, and by their presence the coal can be identified in borings as at Ruddington and elsewhere, since, with the exception of *Lingula*, these fossils do not occur at any other horizon in the Lower Coal Measures. All of them, however, are found at several horizons (pp. 19-25), high up in the Middle Coal Measures, but never in the Upper Coal Measures. Their presence in a boring does not therefore necessarily imply that it is in Lower Coal Measures, though until within recent years this opinion was generally upheld. The fauna mentioned above proves that the shales in which they are preserved were laid down under marine conditions. Below the Alton Coal and at many higher stages both in the Lower and Middle Coal Measures the occurrence of various species of *Carbonicola* [*Anthracosia*], *Anthracomya*, and *Naiadites* are usually regarded as indicating that the sediments containing these fossils were deposited in fresh water or in estuaries. A systematic study of their distribution in Yorkshire and Derbyshire is still needed, and the apparent restriction of certain species to definite horizons awaits further investigation. So far it appears certain that these genera made their appearance in the shales a few feet above the Millstone Grit and that many of the species lived into late Middle Coal Measure times but did not survive the changed conditions indicated by the red beds of the Upper Coal Measures. The genus *Anthracomya* appears to be represented in the Lower Coal Measures only by *A.* cf. *lævis* Dawson, var. *scotica* R. Eth. Jun. The species of *Carbonicola* and *Naiadites* have a wide range, the most restricted form being *Carbonicola robusta* which has not been found above the Top Hard Coal (p. 15) but it descends beneath this horizon to low down in the Lower Coal Measures. It will therefore be seen that a distinction between Lower and Middle Coal Measures based on the distribution of the fauna rests on evidence too imperfect for practical purposes. The plant remains of the Lower Coal Measures have also proved to be of small service, the few forms met with being common to both divisions.

Middle Coal Measures.

In the Lower Coal Measures the sandstones are finer in texture and as a whole more felspathic than those of the Millstone Grit Series. A few, such as the Wingfield Flagstones, can be traced over nearly the entire coalfield, and others have a considerable lateral extension. The associated coals vary greatly in thickness, quality, and development. In the succeeding sub-division of the Middle Coal Measures the sandstones almost invariably contain much clayey material. Beds of pure sand rock, when they occur, either thin out rapidly from the centre of maximum deposition or numerous intercalations of shale-bands so change their character that they become unrecognisable as individual beds. In texture, hardness and composition the sandstones of different horizons closely resemble each other. As a whole therefore they form unreliable guides in the determination of position in the sequence, and their use for this purpose has been and is still a fruitful

source of error. On the other hand, the workable coals are numerous and some of them possess distinctive characters which remain constant over considerable areas. Of these persistent coals the Silkstone Coal at the base and the Top Hard Coal of Nottinghamshire (Barnsley Coal of Yorkshire) 1,000 feet higher in the sequence retain well-marked characters over a large part of the coalfield.

Measures below the Top Hard (Barnsley) Coal.

The Middle Coal Measures, which are over 3,000 feet in thickness, can be conveniently regarded as consisting of two sub-groups in relation to the Top Hard or Barnsley Coal which, apart from its persistence and strongly marked characters, is the one chiefly sought for in the concealed coalfield. The following table gives the position of the coals and of the more important sandstones of the sub-group below this coal, the average thicknesses being represented as in the table of the Lower Coal Measures (p. 9).

Thickness in Feet.	Derbyshire.[1]	Yorkshire.[2]	Thickness in Feet.
90	Measures with *Dunsil Coal and Waterloo Coal*	Measures with irregular coals	210–200
		Swallow Wood Coal, Netherton coals, Haigh Moor coals.	
		Measures with Birdwell and Thornhill rocks	300–310
		Joan, Mitchell, or Parson Coal ...	
340	Measures with *Ell Coal* and *Deep Soft Coal*	Measures with Tankersley Ironstone ...	
		Heward, Flockton Thick, and Adwalton Stone Coal.	
		Measures	
		Flockton Thin, Adwalton Black Bed, Middleton High Main or Forty Yards Coal[3]	
		Measures	240–120
		Fenton's Coal and Black Mine Ironstone[4]	
80	Measures with Deep Hard rock *Deep Hard Coal*	Measures with Park Gate and Birstal rocks	
		Park Gate, Old Hards, Two Yards, Brown Metal or Firthfield Coal.	
190	Measures with *Piper Coal, Hospital Coal, Furnace (Tupton) Coal.*	Measures with thin coals	
		Swilley, New Hards, and Middleton Main coals	
		Measures	
		Silkstone Four-foot, and Middleton Eleven Yards coals	300–260
150	Measures with Silkstone rock Ironstone Measures.	Measures with Silkstone and Falhouse rocks	
		Measures with Claywood Ironstone ...	
	Silkstone, or Black Shale Coal.	*Silkstone, Blocking, or Barcelona Coal.*	

[1] 'The Southern Part of the Derbyshire and Nottinghamshire Coalfield,' *Mem. Geol. Surv.*, 1908.
[2] A. H. Green, 'The Geology of the Yorkshire Coalfield,' *Mem. Geol. Surv.*, 1878, p. 75.
[3] Doubtful if represented south of Flockton, *ibid.*, p. 75.
[4] Wanting north of Dodworth, *ibid.*, p. 75.

The more important coals are the Silkstone, Middleton Main, Tupton, Deep Hard (Parkgate), and Deep Soft ranging from three to six feet in thickness. These form the backbone of the mining industry in the exposed coalfield, but in the concealed coalfield, they have scarcely been touched, except at Clifton Colliery (p. 52), south of Nottingham. Nearly the complete sequence is considered to have been proved in the boring at Edwalton (p. 52) and possibly at Owthorpe (p. 49) and Clipston (p. 49). The upper beds have been pierced for a few hundred feet by most of the shafts and borings between Nottingham and Selby.

Over a large part of the coalfield the Silkstone Coal is the most important seam but it becomes a worthless mixture of shale and coal in the north where, according to Green (*op. cit.* p. 247), it is represented by the Blocking or Barcelona Coal. Numerous dirt partings also make their appearance towards the southern margin of the coalfield where, for this reason, the seam is generally called the Black Shale Coal and less frequently the Clod Coal. The Middleton Main Coal, sometimes regarded as the equivalent of the Silkstone Coal, becomes of importance in the northern part of the coalfield. The Deep Hard (Parkgate) Coal, though variable in thickness and quality, and liable to somewhat extensive washouts, can be recognised over the entire coalfield and is a valuable seam. In the Doncaster district, about 30 or 40 feet below the Barnsley Seam, a coal named the Dunsil, from four to five feet in thickness, has been proved at Bentley Colliery (p. 65) and in the boring at Thorne (p. 66). At Bentley it is stated to be of excellent quality.

The most prominent sandstones are those closely associated with the Silkstone and Deep Hard coals in North Derbyshire and South Yorkshire. They are to be identified rather by the associated seams of coal than by any peculiarities in their composition which corresponds very closely with the sandstones of the Lower Coal Measures, but they are usually coarser than those above the Top Hard Coal.

Chief Fossils in the Measures below the Top Hard (Barnsley) Coal.

The fauna and flora though more abundantly represented and more evenly distributed include the forms found in the Lower Coal Measures. A few species, such as *Carbonicola robusta*, die out; and others such as *Anthracomya modiolaris* make their appearance towards the summit. Not infrequently the shells of *Carbonicola acuta* and *C. aquilina* are massed together in bands from three to four feet in thickness, forming the well known 'Mussel' or 'Cockle' bands of the miner. At present marine shells have been found only in one bed, 300 feet above the Deep Hard Coal in the Clay Cross district, and between 300-400 feet in the Chesterfield area, and there is good evidence to show that this represents the sole incursion of sea water during the deposition of these measures. The band contains the fauna of the shales above the Alton Coal and some gasteropods unknown in the other marine bands of the Coal Measures, but it differs from these in that the

marine shells occur in thin layers and nodules separated by other layers containing species of *Carbonicola* and *Naiadites*. The band is not known in Yorkshire.

Measures above the Top Hard (Barnsley) Coal.

In the Middle Coal Measures below the Top Hard Coal some of the coals and sandstones can be traced through Derbyshire and Nottinghamshire into and over a large part of Yorkshire. The Top Hard or Barnsley Coal has an equally wide extension, but it is difficult to correlate the coals occurring above this seam in Derbyshire and Nottinghamshire with those in Yorkshire. It has been the common practice in Yorkshire to attach names to the many thin seams occurring above the Barnsley Coal, though they merely possess either a local development or change their character so rapidly and so repeatedly that they lose individuality. In Derbyshire and Nottinghamshire a few seams only have been named, and of these it is very uncertain if the same name has been always correctly applied to the same coal. The sandstones, although often of considerable thickness, are, like the coals, local in their distribution, subject to great variations in thickness and composition and are therefore unsatisfactory guides in the correlation of strata occurring in widely separated areas. Of recent years the inspection of borings and sinkings has proved the constant presence of a band of argillaceous limestone resting on a thin coal and succeeded by shales containing a highly specialised fauna. This composite band, here called the "Mansfield Marine Bed," always maintains the same character and has been found in all the borings and sinkings from Gedling Colliery, near Nottingham, to the boring at Thorne 12 miles north-east of Doncaster. In the following table, giving the general succession, the rocks are grouped in their relation to this characteristic band:—

Thickness in Feet.	Nottinghamshire.[1]	Yorkshire.[2]	Thickness in Feet.
700	Measures with thin coals.	Measures ... ... Wickersley, Houghton Common or Pontefract Rock. Measures ... ... Dalton, Brierly or Ackworth rock ... Measures with Great Houghton and Thryberg rocks. *Shafton, Nostel, Billingley and Denaby coals.* Upper Chevet Rock or equivalent measures. Measures with Middle and Lower Chevet rocks and thin coals (Barnsley district), and with *Sharlston Top, Sharlston Low or Crofton Top, Sharlston Yard or Crofton Low coals* (Pontefract district). Treeton or Oaks Rock and equivalent measures.	1,600

[1] From shafts and borings near Mansfield.
[2] From shafts west and south-west of Doncaster.

Thickness in Feet.	Nottinghamshire.[1]	Yorkshire.[2]	Thickness in Feet.
		MANSFIELD MARINE BED.	
600 to 700	Measures with thin coals.	Measures with *Swinton Pottery, Newhill or Steam coals.*	650 to 700
		Woolley Edge Rock or equivalent measures.	
	Clowne Coal? ...	*Aston Common, Wathwood, Meltonfield, Woodmoor, or Wakefield Muck Coal.*	
		Measures	
		Foxearth, Two-foot, Half Yard, Riding or Cat Coal.	
		Measures	
	Measures with thin coals.	*Sough or Yard, Abdy or Winter, Stanley Scale Coal.*	
		Measures	
		Furnace, Beamshaw, Stanley Main Coal	
		Measures with Kents Thin Rock ...	
		Kents Thin Coal...	
		Measures with Kents Thick Rock ...	
	High Hazles Coal	*High Hazles, Kents Thick, or Mapplewell Coal.*	
	Measures with *Coombe Coal.*	Measures with *Barnsley Rider Coal* and Barnsley Rock.	
	Top Hard Coal ...	*Barnsley, Warren House or Gawthorpe Coal.*	

The complete sequence has been definitely proved only at Oxton (p. 57) and Maltby (p. 62) where the Upper Coal Measures are certainly present and where the Top Hard and Barnsley Coal has been proved beyond all question. But over a large part of the field, except to the north-east of Nottingham (Gedling, p. 56, Thurgarton, p. 56), the Upper Coal Measures and some of the Middle Coal Measures were removed by denudation before the deposition of the Permian and Triassic rocks. Since the amount of this destruction of the Coal Measures and their arrangement cannot be determined beforehand, owing to the unconformity of the Permian and Triassic rocks, it is important to ascertain not only the composition of the coals but also the characters of the associated strata and by what means they may be identified. This investigation, however, has not as yet reached a completely satisfactory stage, and in some of the borings, notably at Barlow (p. 66) and Selby (p. 67), the identification of individual coals could not be determined, but in others as at Oxton and Thorne the Mansfield Marine Bed proved a reliable index.

Top Hard, Barnsley or Warren House Coal.

This is the most important seam of the Middle Coal Measures no other approaching it in value, except, perhaps, the Silkstone Coal in Yorkshire. Its superiority mainly depends upon the presence of a band of hard semi-anthracitic coal, known as 'Hards,' which furnishes a first class steam coal. In addition,

[1] From shafts and borings near Mansfield.
[2] From shafts west and south-west of Doncaster.

other parts of the seam yield House, Manufacturing and to a less degree Gas coal. So great is the value of this composite seam that some of the older collieries, in which it has been nearly exhausted, find it more profitable to lease fresh areas and to sink new and deep pits rather than continue the old shafts down to the seams lying below. The progressive and important development of the concealed coalfield in the district of Doncaster hinges upon the existence of the Barnsley Coal, and south of Doncaster on the presence of the Top Hard Coal.

In Nottinghamshire the Top Hard Coal varies in thickness from a little over two feet to over six feet in thickness. It gives the following average section:—

	Ft.	In.
Coal, soft	1	0
,, rifler	1	0
,, best hard	2	0
,, soft	0	4
,, list	0	0½
,, soft	1	2

The lower part of the seam consists locally of cannel from one to two feet in thickness.

A thin seam, Comb, Combe or Coombe Coal occurs at varying distances above the Top Hard. Sometimes it is only separated by a dirt parting, but the name is also given to a seam several feet above the Top Hard, where it probably represents the coal called the Barnsley Rider in Yorkshire. South of the Trent the Top Hard is only known for certainty at Clifton Colliery, where it is 5 feet 11 inches thick, but it here lies so close beneath the water-bearing Bunter Sandstone that it is unworkable. North of the Trent the Top Hard, varying greatly in thickness from place to place, and though occasionally subjected to somewhat extensive washouts, may with great certainty be regarded as extending from its outcrop in the Erewash and Rother valleys eastward as far as the Trent. A local opinion exists that the thickness of the seam decreases eastwards, an opinion based mainly upon a gradual decrease as it is followed to the east in the workings of several collieries between Annesley and Bestwood. But considering the local variations in the thickness of the Top Hard in Derbyshire and Nottinghamshire the arguments brought forward for a general easterly attenuation of this valuable seam hardly justify the condemnation of an area so important as the one bordering the navigable portion of the Trent.

The Top Hard Coal can be traced at the surface and has been followed in colliery workings across the county border, and in Yorkshire as far north as Wakefield where it is known as the Barnsley Coal. In the neighbourhood of Barnsley it reaches a thickness of nine feet and, what is most important, to fully this amount in the recent sinkings at Maltby, Brodsworth, Bentley, and in the boring at Thorne.

In the shafts at Bentley Colliery the seam consists of:—

	Ft.	In.
Soft Coal	4	1
Parting	0	4½
Hard Coal	2	9
Soft ,, ...	2	5½

An average section of the seam in the Elsecar collieries in the visible coalfield gives the following section[1]:—

	Ft.	In.
Baggs	1	6
Top softs	1	6
Hards	4	6
Bottom softs	1	6

North and north-east of Wakefield the seam becomes split up by dirt partings and is known as the Warren House of which the following section at the Prince of Wales Colliery, Pontefract, shows the nature of the change (Green *op. cit.*, p. 393):—

	Ft.	In.	Ft.	In.
Coal	1	2	—	
Dirt	—		0	3
Coal	2	1	—	
Measures	—		16	10
Coal	0	1	—	
Dirt	—		0	5
Coal	0	3	—	
	3	10	17	6

North of the Calder and in the valley of the Aire the dirt partings become thinner and less numerous with a decided improvement in the quality of the coal (Green *op. cit.*, p. 385). Numerous examples of changes in the composition of the Barnsley Coal could be quoted from other districts and other collieries, and even in different parts of the same colliery workings. Such variations in thickness, composition, and quality may be expected to occur in the concealed area, though so far, in the Doncaster district, the coal remains wonderfully uniform. (*See* Sections of Bentley and Thorne, Plate III, figs. 7 and 8.)

The nature of the roof, always an important factor, becomes especially so in deep workings where the cost of maintenance is necessarily higher than in shallow pits. A good roof will more than compensate for a diminished thickness of the coal-seam providing the more valuable 'Hards' remain intact. Between Nottingham and Mansfield, the roof, in the collieries bordering the concealed area or in shafts sunk through the Magnesian Limestone, is always a blue or dark blue shale (bind) generally containing nodules of ironstone. North of Mansfield the shale roof becomes gradually more sandy (stone bind) and occasionally (Whitwell) it is described in the records as being a sandstone rock. In Yorkshire the roof of the Barnsley Coal at the outcrop is not infrequently sandstone, but in pits sunk to the deep it is often a shale or sandy shale. In the deeper explorations at Bentley and Thorne it consists of shales with beds and nodules of ironstone. Several genera and numerous species of plants are frequently very abundant in the roof shales, and by the working miner they are considered to be indicative of this horizon. Between Annesley and Gedling in Nottinghamshire the following shells have been obtained by Mr. R. D. Vernon[2] in the shales above the Top Hard

[1] Green in 'Geology of Yorkshire Coalfield,' *Mem. Geol. Surv.*, 1878, p. 386.

[2] 'Report on the Fossil Fauna and Flora of the southern portion of the Derbyshire and Nottinghamshire Coalfield.' *Rep. Brit. Assoc.* for 1910 (1911), pp. 827–38.

and Coombe coals: *Naiadites modiolaris* (J. de C. Sow.); *N. carinata* (J. de C. Sow.); *N. triangularis* (J. de C. Sow.); *N. quadrata* (J. de C. Sow.); *Carbonicola aquilina* (J. de C. Sow.); *C. similis* (Brown); *C. nucularis* Hind; *Anthracomya modiolaris* (J. de C. Sow.); *A. williamsoni* (Brown).

Measures (200-250 feet).—The measures contain a few thin seams and usually a bed of sandstone. The coals are of no value but noticeable on account of the constancy of their occurrence. The sandstone-rock (Barnsley rock) is usually highly felspathic, thin-bedded, soft, and only occasionally massive. The chief fossils, as mentioned above, occur in the roof shales, but at Brodsworth Colliery *Lingula mytiloides* has been recorded[1] from a thin band of blue shale lying 111 feet above the Barnsley Coal.

High Hazles, Hazles, Kents Thick or Mapplewell Coal.

In Nottinghamshire a coal averaging three feet in thickness, lying between 200-350 feet above the Top Hard, is mentioned in many shaft sections under the name of the High Hazles Coal. It is usually considered to be represented in Yorkshire by the Kents Thick or Mapplewell Coal which is about the same thickness as the High Hazles, and about the same distance above the Barnsley Coal. Locally, the seam becomes of value as a House coal, but it is liable to be split up by dirt partings and bands of shale. In the roof shales at Gedling Colliery Mr. Vernon records (*op. cit.*) the following fossils:—*Carbonicola acuta?* (J. Sow.); *C. aquilina* (J. de C. Sow.); *C. turgida* (Brown); *C. obtusa* Hind; *C. subconstricta* (J. Sow.).

Measures with thin coals (250 to 300 feet).—This group contains a number of seams which vary much in number and thickness from place to place; one of them—the 'Mainbright Coal'—is worked in Nottinghamshire around Hucknall Torkard, and those given in the table (p. 15) are occasionally worked in Yorkshire. In many of the borings (pp. 52-68) no mention is made of these seams, either because they are absent or, owing to their soft character, they have been passed through without being recognised. The sandstones above the Kents Thick, Kents Thin and High Hazles coals, though locally conspicuous rocks, are frequently not developed. At Hucknall Torkard Colliery Mr. Vernon mentions (*op. cit.*) the following shells as occurring in the roof shales of the Mainbright Coal:—*Carbonicola aquilina* (J. de C. Sow.); *C. subconstricta* (J. Sow.); *Naiadites modiolaris* (J. de C. Sow.); *Anthracomya williamsoni* (Brown). From the measures between the Kents Thick and Meltonfield in the shafts at Bentley and Brodsworth Mr. Culpin records[2]:—*Carbonicola* var. *acuta* (Sow.); *C. aquilina, C,* cf. *obtusa* Hind; *Naiadites modiolaris, N. triangularis* (Sow.); *Anthracomya pulchra* Hind. Not only do these

[1] H. Culpin, 'Marine and other fossils in the Yorkshire Coal Measures, above the Barnsley Seam.' *Proc. Yorks. Geol. Soc.*, vol. xvi, pt. iii, 1908, p. 326.

[2] *Proc. Yorks. Geol. Soc.*, vol. xvi, pt. iii, 1908, pp. 321–6; and *ibid*, vol. xvii, pt. i, 1909, pp. 75–6

fossils range above the Meltonfield Coal but they occur in the measures below the Top Hard and Barnsley coals. They are therefore valueless as guides in fixing the position of the group in the general Coal Measure sequence or in the determination of individual coals. In the Nottinghamshire area the identification of the group rests on its position in the general sequence between the Clowne and the Top Hard coals. But in Yorkshire the roof shales of the Abdy Coal have been found by Mr. Dyson at Maltby[1] and by Mr. Culpin at Bentley and Brodsworth to contain the following fossils, all of which indicate that the shales were deposited under marine conditions:—*Lingula mytiloides* J. Sow.; *Pterinopecten carbonarius* Hind, *P. papyraceus* (J. Sow.); *Scaldia carbonaria* Hind, *S. minuta* Hind; *Euphemus urei* (Flem.); *Macrochilina sp.*; *Glyphioceras sp.* No corresponding bed has been found in sinkings or borings in the Nottingham area, though it may have been overlooked.

Aston Common, Wathwood, Meltonfield, Woodmoor, or Wakefield Muck Coal.

These names are given to a coal, which is generally of inferior quality, occurring between 450 and 550 feet above the Barnsley Coal and about 380 feet above the Warren House Coal north-east of Wakefield. Between Sheffield and Wakefield the Wathwood is for the most part of good quality, and has been somewhat extensively worked.[2] Under the name of the Meltonfield Coal it is recognised in the shafts of Bentley, Brodsworth and Maltby.

A coal, generally of inferior quality and much split by dirt partings, occurs in the position of the Wathwood in Nottinghamshire where it receives the name of Clowne or Clown Coal. The Clowne Coal of Shireoaks and Mansfield collieries lies 503 feet and 464 feet respectively above the Top Hard Coal, but in the record of the shaft section of Bestwood Colliery (Plate III., fig. 1) nine miles due south of Mansfield Colliery the Clowne Coal occurs 612 feet above the Top Hard, thus affording the only instance of an apparent increase in the thickness of the Coal Measures in a southerly direction. Since, however, the Clowne Coal is one of a group of seams variable in thickness and quality there is no reason why the coal at Bestwood—2 feet 4 inches thick, occurring 465 feet above the Top Hard Coal—or even one of the lower coals should not represent the Clowne Coal of Mansfield Colliery.

Measures (160 to 250 feet).—In this group the coals are irregularly distributed and of no commercial value—at any rate their value has not been tested. The associated sandstones, of which the Woolley Edge Rock of Yorkshire affords a good example, are also very irregular in thickness and composition. In shales, about 100 feet above the Meltonfield Coal at Bentley and Maltby, the following marine shells have been recorded (*op. cit.*, p. 610) by Messrs. Culpin and Dyson:—*Lingula mytiloides* J. Sow.;

[1] *Rep. Brit. Assoc.* for 1910 (1911) p. 610. [2] Green, *op. cit.*, p. 82.

Orbiculoidea nitida (Phill.); *Myalina compressa* Hind; *Straparollus sp.; Euphemus urei* (Flem.); *Naticopsis sp.; Pleuronautilus costatus* Hind; *Solenocheilus cyclostoma* (Phill.). The band was not noticed at Brodsworth Colliery, and although it is not improbable that it has been overlooked in some of the other sinkings in Yorkshire this is not likely to be the case in the shafts of Sherwood, Mansfield and Gedling collieries, or in the boring at Oxton, in all of which a careful search for fossils was made. Thus, as was the case in the Millstone Grit Series, the repetition of marine conditions was apparently more frequent in later Carboniferous times in the north.

Mansfield Marine Bed.—The somewhat scanty fauna and apparent local occurrence of the marine beds previously mentioned may only indicate a partial and temporary break-down of a seaward barrier which gave the sea access to the swampy lagoons in which the greater part of the sediments and vegetable matter forming the Coal Measures accumulated; but in whatever way they originated these marine beds cannot, so far as the evidence allows, be considered other than due to local causes. After the incursion of the sea, represented by the fossils in the shales above the Meltonfield, about 100 feet of ordinary grey measures were deposited, and then there can be no doubt that the whole region was depressed, and the Mansfield Marine Bed was formed. The prolific, varied and characteristic fauna of this bed, its thickness and widespread distribution in Nottinghamshire and Yorkshire, certainly indicate an extensive and possibly prolonged occupation of the area by the Carboniferous sea. The fauna, also, is so reminiscent of that above the Gin Mine Coal, which occurs high up in the Middle Coal Measures of North Staffordshire,[1] as to suggest that the depression continued across the Pennine region.

The bed, as previously mentioned (p. 14), was first detected at Gedling Colliery, near Nottingham, and subsequently in the shafts of Sherwood Colliery; but its value as a fixed horizon with a definite fauna was not realised until after the examination of the material brought to the surface in sinking the shafts of Mansfield Colliery.[2]

In Yorkshire this bed as well as the marine bands previously mentioned have been closely investigated by Mr. H. Culpin at Brodsworth[3] and Bentley[4] and by Mr. Dyson at Maltby.[5]

The most interesting life forms belong to the invertebrates. Of the Mollusca, the genera *Carbonicola, Anthracomya* and *Naiadites* are unrepresented and clearly show that whatever may have been the habitat of these animals they were unable to live side by side with purely marine forms. The remains of fishes are not plentiful, but among them may be mentioned the rare spine *Listracanthus wardi.*

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[1] 'The Geology of the North Staffordshire Coalfields,' *Mem. Geol. Surv.*, 1905, p. 320.

[2] 'Summary of Progress' for 1902, *Mem. Geol. Surv.*, pp. 14–6; for 1905, pp. 21–2; and 1906, p. 77.

[3] *Proc. Yorks. Geol. Soc.*, pt. iii, vol. xvi, 1908, pp. 321–6.

[4] *Ibid.*, pt. i, vol. xvii, 1909, pp. 75–6.

[5] *Rep. Brit. Assoc.*, 1910 (1911), Sheffield Meeting, p. 610.

The chief fossils, exclusive of fish and plant remains, recorded from Mansfield, Brodsworth, Bentley and Maltby collieries, are given in the list below:—

[C = Culpin Collection; D = Dyson Collection; S = Survey Collection.]

Crinoid stems, C.

Spirorbis sp., C, S.

Chonetes laguessiana *de Kon.*, mut. *θ Hind*, C, D, S.
Lingula mytiloides *J. Sow.*, C, D, S.
Orbiculoidea nitida (*Phill.*), C, D.
Productus anthrax *Hind*, D.
,, sp., C, S.
Rhipidomella *cf.* michelini (*Leveillé*), C.
Rhynchonellid, D.
Spiriferina?, S.

Allorisma sp. nov., S.
Aviculopecten culpini *Hind*, C.
,, sp. nov., S.
Ctenodonta laevirostrum (*Portl.*), C, D, S.
Ctenodonta *cf.* undulata (*Phill.*), S.
Edmondia sp., C.
Myalina compressa *Hind*, C, D.
,, *cf.* compressa *Hind*, S.
Nucula aequalis *J. de C. Sow.*, C, D.
,, gibbosa *Flem.*, S.
,, *cf.* gibbosa *Flem.*, C, D.
,, luciniformis *Phill.*, D.
,, sp. nov., S.
Nuculana acuta (*J. de C. Sow.*), C, D.
,, *cf.* acuta, S.
,, attenuata (*Flem.*), S.
Posidoniella laevis (*Brown*), C, D, S.
,, sulcata, *Hind*, C, D, S.
Pseudamusium anisotum (*Phill.*), D.
,, fibrillosum (*Salt.*), C, D, S.
,, sp., S.
Pterinopecten carbonarius *Hind*, C, S.
,, papyraceus (*J. Sow.*), C, D, S.

Sanguinolites sp. nov., C.
Scaldia carbonaria *Hind*, C, D.
Schizodus antiquus *Hind*, D.
Solenomya primaeva (*Phill.*), C.
Syncyclonema carboniferum *Hind*, C, D.

Bellerophon sp., D.
Euphemus d'orbignyi (*Portl.*), C, D.
,, *cf.* urei (*Flem.*), C, D, S.
Loxonema acutum *de Kon.*, C, D.
,, ashtonense *H. Bolton*, D.
Raphistoma radians (*de Kon.*), C, D.

Coelonautilus sp., C.
Dimorphoceras gilbertsoni (*Phill.*), C, D.
Ephippioceras clitellarium (*J. de C. Sow.*), D.
Gastrioceras carbonarium ? (*von Buch*), C, D.
Glyphioceras *cf.* micronotum (*Phill.*), D.
,, ? paucilobum (*Phill.*), C.
,, phillipsi ? *Foord & Crick*, D, S.
,, reticulatum (*Phill.*), C, D.
,, sp., S.
Orthoceras asciculare *Brown*, C, D.
,, *cf.* asciculare *Brown*, C, S.
,, koninckianum (*d'Orb.*), C, D.
,, ? scalare (*d'Arch. & de Vern.*), C.
,, steinhaueri *J. Sow.*, C.
Pleuronautilus costatus *Hind*, C, D.
,, *cf.* pulcher *Crick*, C.
Solenocheilus sp., C.
Temnocheilus carbonarius *Foord*, C.

Of the fossils peculiar to the band, and which distinguish it from the other marine beds in the Coal Measures, there may be selected *Nucula*, *Pseudamusium*, *Syncyclonema*, *Posidoniella sulcata*, and *Pterinopecten carbonarius*, which occur in considerable abundance and have been found even in the limited material afforded

by a small core, such as that of the Thorne Boring (p. 66). There is always a great abundance of goniatites and of *Pterinopecten papyraceus*.

The components of the zone maintain the following characters in ascending sequence:—Coal (3 in. to 1 ft.); grey shales (0 to 3 ft.); blue earthy limestone (0 to 2 ft.); light blue shales (10 to 25 ft.). The coal, resting on a fireclay at the base, affords an example of a thin seam persisting over wide areas, and followed by a set of conditions very different from those under which the vegetable matter now forming the coal seams is supposed to have accumulated. The grey shales immediately above the coal are a feature of the southern area between Oxton and Mansfield. They usually contain fragments of plants and were either not deposited or were removed in the north by contemporaneous erosion. The earthy limestone (' cank ' of the miner) occurs either as a band varying from a few inches up to two or three feet in diameter or as a layer of nodules. It has been found in every sinking examined between Gedling and Bentley. It is absent at the Thorne and Armthorpe borings but this may be due to its nodular form and to the boring tool having passed between two nodules. The rock is intensely hard and flinty. When unweathered it is of a dark blue colour, but after a brief exposure to the air it becomes light brown. Though it contains marine shells these are difficult to obtain whole owing to the flinty and jointed character of the rock. The blue shales over the limestones are everywhere of the same fine-grained character, greasy to the touch, and containing numerous fucoid-like markings. Fossils are most abundant in the shales resting immediately on the limestone, *Lingula* being the fossil last to disappear.

The position of the band may be considered in its relation to the Wathwood Coal of Yorkshire and to the Clowne Coal of Nottinghamshire, and what is a more reliable datum, to its distance above the Top Hard or Barnsley Coal.

Position of the Mansfield Marine Bed.

	Colliery or Boring.	Feet above Wathwood Coal.	Feet above Clowne Coal.	Feet above Top Hard or Barnsley Coal.
Yorks.	Thorne	? 160	—	566
	Bentley	184	—	676
	Brodsworth ...	222	—	705
	Maltby	244	—	708
Notts.	Sherwood	—	? 215	733
	Mansfield	—	163	629
	Oxton	—	? 103	528
	Gedling	—	Below the Clowne	352 (*see* p. 56)

On comparing the geographical position of these localities (map, Plate I.) it will be seen that the measures between the Mansfield Marine Bed and the Barnsley or Top Hard Coal gradually decrease in thickness from north to south. Between Bentley and Mansfield in a distance of 28 miles the diminution

amounts to only 47 feet; but south of Mansfield the attenuation of the measures appears to be at a more rapid rate. A diminution in the thickness of the strata between the Mansfield Marine Bed and the Barnsley Coal from west to east is shown by the comparison of Brodsworth with Bentley and Thorne, and a similar thinning of the measures occurs between the Mansfield Marine Bed and the Top Hard Coal if the section at Sherwood Colliery is compared with that of Mansfield. The evidence, however, cannot be regarded as conclusive of a general decrease eastward.

Measures between the Mansfield Marine Bed and the Upper Coal Measures.

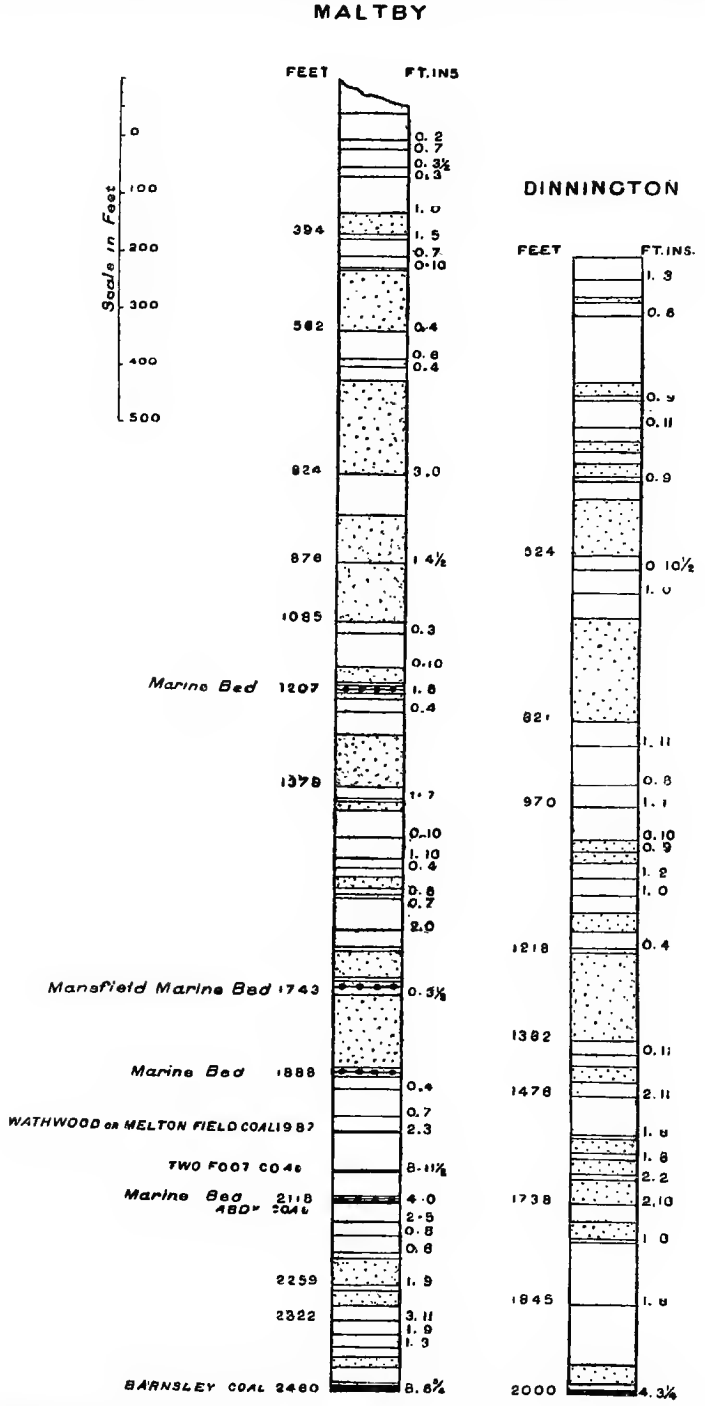
The Coal Measures above the Mansfield Marine Bed show a greater variation in thickness and composition than occurs in any other part of the Upper Carboniferous rocks. Perhaps the most noticeable feature consists in the great development of thick bedded sandstones in the central region and their almost total absence in the south, with a consequent very marked diminution in the thickness of the group. This is clearly shown by the comparison of the shaft section of Maltby Colliery (Fig. 2, p. 24) with the boring at Oxton (Plate III., fig. 2), 27 miles south-south-east of Maltby, where at both localities the Upper Coal Measures are present and, therefore, the full thickness of the measures is represented.

At Maltby the thickness of the strata between the Upper Coal Measures and the Mansfield Marine Bed amounts to 1,536 feet, and at Oxton to 755 feet, which represents an attenuation of nearly 29 feet per mile, a sharp contrast with the attenuation of six feet per mile observable in the group between the Mansfield Marine Bed and the Top Hard Coal.

In Nottinghamshire generally, though not recorded at Oxton (*see* p. 48), numerous thin coals from a few inches up to three feet in thickness occur at different horizons up to within a few feet of the red Upper Coal Measures. None are workable and they usually remain unnamed. The Yorkshire measures contain several workable seams of which the Sharlston, 500-650 feet above the Wathwood, and the Shafton, 758 feet above the Wathwood at Cadeby Colliery, are the chief. At Bentley Colliery (p. 65) and at Brodsworth (p. 65) a coal, from four to five feet in thickness, occurring at 589 feet and 623 feet respectively above the Wathwood, is not infrequently identified as the Shafton Coal. Workable coals in approximately the same position have been proved at Haxey (p. 96), Thorne (p. 115), and Selby (p. 112); and it may be assumed that generally there extends over the East Yorkshire Coalfield a workable seam of fair quality and thickness lying from 500 to 800 feet above the Wathwood Coal. Occasionally, as at Maltby and Dinnington collieries, the Wathwood is the highest coal of any considerable thickness in the Middle Coal Measures.

The difficulty experienced in the correlation of the seams above the Barnsley Coal is illustrated by the shaft sections of these two collieries (Fig. 2, p. 24). In the older sinking (Dinnington) the Mansfield Marine Bed is not mentioned, so that the coals cannot be correlated with those at Dinnington, except on their relative

FIG. 2.—*Shaft Sections to illustrate the character of the Middle Coal Measures above the Barnsley Coal in the South Yorkshire Coalfield.*



Numbers on left in both sections give depths from surface ; those on right

height above the Barnsley, and on this comparison it will be seen how variable are the coals in thickness and position. The two sections thus illustrate the value of the marine bed as a datum.

The chief sandstones above the Mansfield Marine Bed are given in the table (p. 14).[1] They vary considerably in thickness and composition and cannot be readily identified in many of the sections. Except at Maltby, Dinnington, and Cadeby the measures above the Shafton Coal have been, for the most part, removed by post-Carboniferous denudation. As the sandstones lose their individuality in Nottinghamshire there is little to be gained in attempting to identify the several sandstones in the Maltby sinking with those occurring in sinkings and borings often situated many miles apart. They are, therefore, left unnamed in the sections illustrating the concealed coalfield (Plate III).

Chief fossils above the Mansfield Marine Bed.—The most important fossil for zonal purposes is the shell *Anthracomya phillipsi*. Crushed specimens occur at several horizons, and are especially abundant in beds of black shale between the Shafton Coal and the base of the Upper Coal Measures. Though isolated specimens have been met with below the Wathwood Coal they have not been found yet below the Top Hard or Barnsley Coal. The fossil can, therefore, be regarded as characteristic of the Middle Coal Measures above this important seam. With the exception of the small shell, *Anthracomya calcifera* Hind, found in the Upper Coal Measures at Thurgarton, it represents the sole survivor of the genus. Of the other freshwater and estuarine shells, *Naiadites modiolaris* ranges above the Shafton Coal; but the genus *Carbonicola* does not appear to have survived the Mansfield Marine Bed.

A brief, and possibly the latest incursion of sea-water within the area in Carboniferous times is indicated by the fossils found in a bed of shale 20 to 30 feet above the Shafton Coal and 452 to 455 feet above the Mansfield Marine Bed at Bentley and Brodsworth collieries. The band was first noticed by Mr. Culpin (*op. cit.*) at Brodsworth and subsequently at Bentley; more recently it has been recorded by Mr. Dyson (*op. cit.*) at Maltby Colliery where it lies 516 feet above the Mansfield Marine Bed.

The fossils at Maltby Colliery consisted of:—*Lingula mytiloides* J. Sow.; *Orbiculoidea nitida* (Phill.); *Myalina compressa* Hind; *Nuculana acuta* (J. de C. Sow.); several species of goniatites and *Listracanthus wardi*. The occurrence of *Posidonomya* at a higher level below the Houghton Common Rock by Green (*op. cit.*, pp. 468 and 753) suggests another marine bed, but there were no signs of its presence at Maltby either in the cores of the preliminary boring or subsequently in sinking the shafts.

Upper Coal Measures.

The Lower and Middle Coal Measures on the east side of the Pennine Range agree in general sequence and lithological character with the same divisions on the west side. In North Staffordshire, South Staffordshire, Warwickshire, and North

[1] For a full description of the rocks *see* Green, *op. cit.*, pp. 431–86.

Wales the Middle Coal Measures are succeeded by a group of strata several hundred feet thick, of a peculiar character, usually red, and containing only a few thin and worthless seams of coal.

It was for a long time considered that these red barren measures were unrepresented on the east side of the Pennine Hills unless by a few feet of red clays near Conisborough and possibly by the red sandstones at Rotherham and in the shafts of Shireoaks Colliery and in the boring at Haxey.

A similar group of barren red measures comparable in sequence though not in thickness with those of Staffordshire was first recorded from the boring at Thurgarton,[1] and were subsequently identified in part at Oxton and Maltby.

From borings it is now known that these upper measures have only a limited extension in Nottinghamshire, and in Yorkshire also they have been denuded mostly before the deposition of the Magnesian Limestone.

The complete sequence of the strata occurs only at Thurgarton (Appendix, Sect. 22, p. 118). The lower (Etruria Marl) group consists chiefly of unstratified red clays among which occur thin bands of green grits (identical with the Espley Rocks of Shropshire and Staffordshire) of which the material has been mainly derived from the waste of igneous rocks. The green grits are unknown elsewhere in the Carboniferous sequence and are characteristic of the Etruria Marl group throughout the Midlands. The Middle (Newcastle) group is composed of grey sandstones and shales with a thin seam of coal three inches thick. The red sandstones and marls of the highest (Keele) group represent the lower subdivision of the Salopian Permian of Professor Hull, but, as previously mentioned (p. 8), these red beds are now considered to be of Coal Measure age. The boring at Thurgarton yielded confirmatory evidence of the Carboniferous age of these red beds by the presence of typical Coal Measure plants, such as *Pecopteris arborescens* (Schloth.), *P. miltoni* (Artis); *Neuropteris rarinervis* Bunbury, and *Sphenophyllum*.

[1] W. Gibson, *Quart. Journ. Geol. Soc.*, vol. lvii, 1901, p. 262.

CHAPTER III.

THE PERMIAN, TRIASSIC, AND SUPERFICIAL ROCKS.

The Lower Coal Measures pass up into the Middle Coal Measures and these into the Upper Coal Measures without showing clear signs of a break in the sequence or of a pause in sedimentation. The sandstones were doubtless deposited at a quicker rate than the beds of shale, and these more rapidly than the seams of coal, but proofs are wanting of a prolonged elevation and erosion of the Carboniferous rocks during any part of the period.

After the deposition of the Carboniferous rocks there followed a time during which they were uplifted and worn deeply down by erosion into a nearly plane surface on which the Permian and Triassic sediments, which form the cover of the coalfield, were afterwards overspread. The extent to which the Carboniferous rocks suffered erosion is most clearly illustrated north-east of Leeds, where the whole of the Coal Measures, amounting to 5,000 feet of strata, were thus removed before the Magnesian Limestone was deposited.

Permian.

The complete sequence (*see* table of formations, p. 2) of the Permian rocks occurs throughout the Yorkshire area; but in Nottinghamshire, south of Warsop, the Upper Marl and Upper Limestone gradually thin away one after the other, until at Bevercotes (p. 78) these subdivisions are represented by 25 feet of limestone and three feet of marl, but at South Scarle (p. 59), 11 miles south-east of Bevercotes, the Upper Marl and Upper Limestone are again of considerable thickness. Due south of Bevercotes the Upper Marl and Limestone thin out; each of the subdivisions below the Upper Limestone also becomes reduced in thickness until the Permian formation finally disappears on the north-western outskirts of Nottingham. The variation in the thickness of the different members of the Permian series between Selby in the north and Thurgarton in the south is illustrated by Plate II.

Basal breccia and sands.—Between Nottingham and Bolsover, and in all the borings and shafts to the east, the lowest bed of the Permian consists of a hard breccia (conglomerate and 'mingled' rock of some records) varying from a few inches to 8 feet. It is composed of angular, sub-angular, and rounded fragments derived from the Carboniferous rocks, together with pieces of slate, jasper, chert, and other rocks from older formations, all firmly set in a sandy calcareous cement. When unweathered it resembles concrete, and is so unlike any rock of the underlying Carboniferous formation that it affords a reliable index to the base of the Permian. The breccia disappears a short distance north of Bolsover, where its place is taken by a bed of loosely consolidated sand from a few feet to 20 feet in thickness. It appears to reach its maximum development near the outcrop, but

is generally present in borings to the east. Where, as at Selby (p. 67), the bed rests on a soft Coal Measure sandstone it is difficult to separate the older from the newer formation.

'*Marl Slates.*'—The basal breccia and sands are succeeded by grey, frequently mottled, shales and marls usually calcareous with intercalations of calcareous flags and thin limestones in Nottinghamshire, but consisting entirely of shale in Yorkshire. To this group the inappropriate term 'Marl Slates' has been given though the beds are not cleaved nor are they ever of a slaty character.

The 'Marl Slates' show many and irregular variations in thickness. As a whole they thicken to the east, but they do not share in the regular expansion northward so noticeable in the Middle and Upper Permian limestones and marls. Thus at Oxton the group is 85 feet thick and only three feet at Selby, while between Oxton and Selby many variations in thickness occur, and occasionally, as at Barlow, both the shales and sands are absent. These deposits, especially where they consist of grey shales and calcareous flags, closely resemble the binds (shales) and stone-binds (sandy shales) of the Coal Measures with which they have been and are still often included in many records of shafts and borings. The fossils of the Permian strata are, however, very different from those of the Coal Measures, and are generally present, though sometimes sparsely distributed throughout the beds.

The commonest fossils are the casts of shells belonging to the genera *Schizodus*, *Bakevellia*, *Pleurophorus*, and *Productus*, the latter genus being represented by *Productus horridus*, a species quite distinct from the productids in the marine bands of the Coal Measures. In addition to casts, the shales invariably contain the chitinous shell, *Lingula credneri*, which is a much stouter and broader form than *L. mytiloides* of the Coal Measures.

Lower Limestone.—The 'Marl Slates' are succeeded by beds of dolomitic limestone, of a somewhat flaggy structure in the south, but becoming more massive as the beds are traced northward. Locally, aronnd Mansfield, beds of red and white sandstone are intercalated, and near Nottingham the limestones contain some sand grains mingled with granules of dolomite, giving the rock the appearance of a calcareous sandstone for which it has been mistaken in some of the sinkings and borings. When massive, the limestone is generally compact, hard, and of a brownish-yellow or cream colour. Numerous fissures and joints often cross the bedding-planes as well as irregular channels and spaces, some of which are open and yield considerable volumes of water, holding in suspension a fine calcareous silt which in the shafts of Bullcroft Colliery clogged the pumps and rendered them useless.

The essential constituent of the Lower Limestone is the complex double carbonate of lime and magnesia or dolomite, occurring as small rhombohedral crystals. As accessory minerals, beds, stringers and irregular patches of gypsum and anhydrite occur throughout; grains of galena and iron pyrites are also occasionally present in Nottinghamshire and become of common occurrence in Yorkshire, where also the gypsiferous masses are more strongly developed.

The Lower Limestone from its commencement near Nottingham gradually increases to a thickness of 312 feet in the Selby Boring on the northern margin of the area. An expansion takes place eastward, though with a tendency for the Marl Slates to be locally developed at the expense of the Lower Limestone.

The fossils of the Lower Limestone at its outcrop are a few obscure casts of shells (*Schizodus, &c.*), and more rarely of reptilian footprints (Mansfield). The shells represent dwarfed forms, but at Bentley Colliery the lower beds contained numerous and apparently fully grown individuals of *Productus horridus* (J. Sow.) and *Spirifer alatus* (Schloth.).

Middle Marls.—From the boring at Bevercotes in the south to that of Selby in the north a group, from 74 to 153 feet thick, of bright-red shaly clays and marls, intervenes between the Lower and Upper Magnesian Limestones. From their position in the sequence the beds are known as the Middle Permian Marls, and it is generally considered that south of Bevercotes they are represented by the red clays which succeed the Lower Limestone, though they here appear to graduate upwards and in places to interdigitate with the lower beds of the Bunter formation.

In Nottinghamshire this sub-division varies irregularly from under 10 feet to the maximum of 153 feet at Bevercotes. It consists chiefly of red clays and marls with intercalations of friable red sandstones not unlike those of the Trias, but usually of a flaggy character and frequently dolomitic. On approaching the Yorkshire border, veins, nodules, and layers of gypsum and anhydrite from a few inches to a foot or more in thickness make their appearance. The sandy beds are then not so generally developed, but the dolomitic flags, occasionally becoming dolomitic flaggy limestones, persist. The thickness of the group varies from 60 to 120 feet. At its base a bed of rock-salt, 20 feet thick, was passed through in the Barlow Boring (p. 72), and is the only recorded occurrence of rock-salt in the Permian deposits of Great Britain. In Cheshire, Staffordshire, Shropshire, Worcestershire and in the north of Ireland rock-salt is confined to the Keuper or upper division of the Triassic System. The saliferous marls of Middlesborough, on the hitherto unknown occurrence of rock-salt in deposits of Permian age in this country, have also been referred to the Trias.[1]

Upper Limestone.—This is a fine-grained compact rock resembling the Lower Limestone and similarly composed of the double carbonate of lime and magnesia. As previously mentioned (p. 27) the Upper Limestone occupies a more restricted area than the inferior groups of the Permian. It first appears in the south-east at Scarle as a bed 44 feet in thickness, which has diminished to 25 feet of limestone and shale at Bevercotes. Thence northward it gradually expands to a thickness of 109 feet at Selby and remains as a distinct bed throughout the Yorkshire area. It is fossiliferous, but usually less so than the Lower Limestone.

Upper Marls.—A group of brightly-coloured red shaly clays and marls, from under 10 feet in the south to 105 feet thick in

[1] E. Wilson, *Quart. Journ. Geol. Soc.*, vol. xliv, 1888, pp. 761–82.

the north, invariably occurs between the Upper Limestone and Bunter formation; interspersed with the marls are lenticular beds of red sandstone of Bunter type. Gypsum and anhydrite in veins, nodules, clusters, or in distinct beds—sometimes as much as 20 feet in thickness—are found in all the Yorkshire sections. One bed of anhydrite near the summit appears in most of the records, but it is not persistently developed and it would be expected that these bands, which were chemically deposited, would vary much in thickness and distribution, as the local conditions which governed their precipitation changed.

TRIAS.

The junction of Permian and Trias, unlike that of Permian and Carboniferous, suggests in many places an upward passage from one system to the other. The Triassic sediments increase in thickness from south to north and from west to east at a rate proportionate to that of the Permian deposits. The discordance between the two systems, if any, is slight and has no practical significance, while the overlap of the Keuper on to the Carboniferous rocks observed at the southern end of the Derbyshire Coalfield does not affect the present area. Owing, however, to continued depression, the sediments of the Triassic period spread beyond the limits of the Permian deposits so that they extend southward beyond the Trent into Leicestershire.

Of the different divisions of the Triassic System (*see* table of formations, p. 2), the Rhætic and Keuper Marls retain their individuality over the whole area. Generally in Nottinghamshire the Keuper sandstones are separable by their lithological characters from those of the Bunter formation; but in Yorkshire all the sandstones below the Keuper Marl belong to one type, and it is a matter of opinion whether they should be referred to the Keuper or the Bunter formation, but in character they resemble the soft brick-red sandstones of the Bunter rather than the brown, harder sandstones of the Keuper. Moreover, while the Bunter sandstones, except for the absence of pebbles in the north, retain the same character throughout the area, the Keuper sandstones assume a more and more shaly facies as they approach the Yorkshire border, until they become inseparable from the Keuper Marl.

The complete Triassic sequence has been proved only at Owthorpe and South Scarle. In the Owthorpe Boring the total thickness amounts to 1,056 feet, and to 1,450 feet at South Scarle, representing a northerly increase of 394 feet in 21 miles. The Bunter shows an increase of 267 feet, but the Keuper Marls are only 66 feet thicker at South Scarle than at Owthorpe.

Bunter.—The Bunter formation of Nottinghamshire is supposed to be separable by differences of texture and composition into two sub-divisions, the Lower Mottled Sandstone without pebbles below and the Pebble Beds above.

The Lower Mottled Sandstone is composed of red, loamy sands with a basal conglomerate, 10 feet thick, over the southern area (p. 51).

The Pebble Beds consist of rather coarse red sands with an admixture of pebbles of quartzite and other rocks disseminated through the body of the sandstone and only rarely clustered into narrow strings and small pockets. This is the common type in Nottinghamshire. By the gradual reduction in the size and number of the pebbles, and by the introduction of bands of marl and beds of loamy sand to the north of Bevercotes, the subdivision assumes all the characters of the Lower Mottled Sandstone from which it is not distinguishable over the northern district. A few scattered pebbles of quartzite are present in the sub-division at Armthorpe, but are absent at Thorne, Barlow, Selby and elsewhere to the north, though sandstones containing pellets of marl have been recorded as pebbly sandstones in some of the boring records.

The Bunter formation increases from a thickness of 274 feet at Owthorpe to 681 feet at Bevercotes. North of Bevercotes the Bunter sandstones are inseparable from those of Keuper age, but 734 feet at least must be allowed for the Bunter in the Thorne Boring.

No determinable fossils have been found in the Bunter formation of Nottinghamshire and Yorkshire.

Keuper.—The Keuper formation in Nottinghamshire is separable into two sub-divisions: the lower, called the "Waterstones," consists of thin flaggy soft sandstones, deep red or more rarely, greyish in colour; while the Upper or Marl sub-division is composed of finer sediments.

Between Clipston and Bevercotes the basal beds of the Waterstones usually consist of pale-grey shales and sandy beds, which are distinct from the red sandstones and marls of the Bunter, but in South Yorkshire they are either feebly developed or they occur at several horizons throughout the sandstones between the Keuper Marl and Permian. In Nottinghamshire, at the base of the Waterstones, and lying in hollows of the Bunter Sandstone, there occur in many places lenticular masses of hard conglomerate or coarse pebbly sandstones, from an inch or two up to three feet in thickness, which indicate that there may have been some erosion of the Bunter before the deposition of the Waterstones, but in Yorkshire these beds are absent.

As regards their upper boundary the Waterstones merge indefinitely into the Keuper Marl. Gypsum, although found in greater abundance in the Keuper Marl, also occurs in the Waterstones. Since, therefore, its lower limits are not defined in Yorkshire and its upper limits cannot be fixed throughout the area, the sub-division possesses little practical value. It is serviceable in comparing the sections between Owthorpe and Bevercotes; but it leads only to confusion when applied to those to the north-east of Bevercotes as in the published accounts of the borings at Haxey and Scunthorpe.

The thickness of the sub-division, for the reasons given above, cannot be stated with any strict accuracy; but making allowance for the difficulty in separating the Waterstones from the Keuper

Marl it appears to diminish northward from a thickness of 192 feet at Clipston to 150 feet at Thurgarton, yet it is 174 feet at Kelham and over 200 feet in the Greet valley.

No fossils have been recorded from any of the borings and sinkings passing through these beds, but the remains of fishes, reptilian footprints, and traces of land-plants are known from surface exposures near Nottingham.[1]

The sub-division of the Keuper Marl retains a nearly uniform composition throughout the area.

Silty red clays form the predominant constituent, but with them there occur intercalations of thin, very fine-grained sandstones (skerries), from a few inches to 10 feet thick, which are most numerous in the country north of Nottingham. The predominant deep-red colour of the marls disappears near the top, the uppermost 20 feet or so being of a pale greenish-grey tint, whence this portion of the series is known as the "Tea-green Marl." Gypsum, in the form of veins and strings, occurs in almost every part of the sub-division, but it is principally concentrated in the upper beds.

As previously mentioned (p. 30) the Marls graduate downward into the Waterstones, but the black shales of the Rhætic always clearly determine their upward limit. The full thickness is proved at Owthorpe, in the south-east; at South Scarle, 22 miles north-east of Owthorpe; and at Scunthorpe, 28 miles north of South Scarle. The respective thicknesses are 627, 688 and 864 feet. The increase therefore takes place at a much less and more uniform rate than in the case of the Bunter sandstones.

Rhætic.—This division of the Triassic System rarely exceeds a thickness of 30 feet; but though thin it is invariably present. It is sub-divided into the *Avicula-contorta* shales below, consisting of thinly-laminated, exceedingly fossiliferous, black shales; and into the 'White Lias' above composed of grey shales and thin fossiliferous limestones. Its outcrop forms a beading along the eastern and southern margins of the proved coalfield, beyond which explorations in search of coal are not likely to be undertaken, at least for some time to come.

The full thickness was penetrated at Owthorpe (p. 108) and South Scarle (p. 59).

Superficial Deposits.

In contrast with the drift-covered uplands and plains of Lancashire, Cheshire, North Staffordshire, and the coalfields of Durham and Northumberland, the oldest (Glacial) of the Superficial Deposits are but feebly represented, and over large tracts they are absent. They occur sometimes in thin patches capping the hills, but rarely, if ever, along the floors of the existing valleys. Where they are present in any thickness, as at Bentley Colliery, they have evidently filled up old hollows, and for this reason their existence cannot be detected on the plains, neither can their thickness be estimated; and channels, filled with Drift

[1] 'The Geology of the Country around Nottingham,' *Mem. Geol. Surv.*, 1910, pp. 37–8.

TABLE GIVING THE THICKNESS OF THE COVERING FORMATIONS AS PROVED BY SHAFT-SINKINGS (*c*), AND BORINGS (*b*).

The arrangement is from North to South.

Measurements are in Feet and Inches.

Name of Formation.	Selby (*b*). 16, O.D.	Barlow (*b*). 16·1, O.D.	West Bank, Carlton, Snaith (*b*). 20, O.D.	Thorne (*b*). 20, O.D.	Brodsworth (*c*). 122, O.D.	Bentley (*c*). 21, O.D.	Aumthorpe (*b*). 50, O.D.	Haxey (*b*). 18, O.D.	Manton (*c*). 120, O.D.	Bevercotes (*b*). 96, O.D.	S. Scarle (*b*). 35, O.D.	Sherwood (*c*). 380, O.D.	Mansfield (*c*). 386·86, O.D.	Oxton, (*b*). 260, O.D.	Kelham (*b*). 40, O.D.	Thurgarton (*b*). 57, O.D.	Gedling (*c*). 185, O.D.	Wilford (*b*). 80, O.D.	Edwalton (*b*). 95, O.D.	Ruddington (*b*). 100, O.D.	Clipston (*b*). 180.	Owthorpe (*b*). 200, O.D.
Superficial ...	70	94	60	60	—	100	20·7	32	—	9·9	21	—	·10	—	18·6	21	7·3	21	10	7	11	—
Lias	—	—	—	—	—	—	—	—	—	—	29	—	—	—	—	—	—	—	—	—	—	12·6
Rhætic and Keuper Marl.	—	—	—	—	—	—	—	105·7	—	—	908·6	—	—	—	397·6	92·9	—	192	389	386·0	509	661·6
Keuper Waterstones.	—	—	—	—	—	—	—	1042·11	—	27·9		—	—	—	174	150	69·0		50·8	73·9	192	121·6
Bunter	590	601	466·6	856·6	—	28·6	518·5		213·4	681·10	541·6	14	273·10	374·6	671	493·5	385·2	246	254·4	220·7	258	273·6
Upper Permian Marl.	109	105	102·6	131	—	56·4	68·10	58	20	3·2	118·6	absent	absent	absent	absent	absent	absent					
Upper Permian Limestone.	109	103	101	92	—	53·2	42·8	84	22·6	25·6	43·6	absent	—	absent	absent	absent	absent					
Middle Permian Marl &c.	74	118	118	125	79	34	114·9	132·9	68·8	153·4	150	absent	14·2	9·2	35	68·10						
Lower Permian Limestone.	312	284	215	261	110	224·10	194·9	273	260·6	202·3	207·	132·6	68·6	44·4	82·6		46·1	absent south of the Trent.				
Marl Slates ...	3	nil.	nil.	12	nil.	24·6	11	?9	35·10	26·6		88·3	98·7	85·6	21·6	24·0						
Breccia (*b*) or ...	—	nil.	—	—	nil.	nil.	nil.	nil.	nil.	6 (*b*)	1 (*b*)	8 (*b*)	2·11 (*b*)	2·6 (*b*)	1 (*b*)	·6 (*b*)	·8					
Sands (*s*) ...	17 (*s*)	nil.	25 (*s*)	1 (*s*)	nil.	nil.	nil.	nil.	nil.	—	—	—	—	—	—	—						
Total ...	1284	1305	1091·	1538·6	189	521·4	971	1737·3	620·10	1136·1	2020	242·9	458·10	516	1401	850·6	508·2	459	704·0	687·4	970	1069

gravels and sands, of even greater depth than the one at Bentley, may exist beneath the nearly level ground between Doncaster and the Ouse. Of still minor importance, as affecting mining operations, are the later gravels and silts bordering the Trent and spreading over the plain north of Doncaster.

For an account of the Liassic rocks, of which a few feet were proved at Owthorpe, and which border the area on the east, and also occur at the surface in the south-east, the following Memoirs of the Geological Survey may be referred to:—(1) The Geology of S.W. part of Lincolnshire, &c., 1885; (2) The Jurassic Rocks of Britain, Vol. III. (1893), and Vol. IV. (1894); (3) Geology of the Country around Lincoln, 1888; (4) Water Supply of Lincolnshire, 1904; (5) Water Supply of the East Riding of Yorkshire, 1906; (6) The Geology of the Melton Mowbray District and South-East Nottinghamshire, 1909. The two memoirs last mentioned give numerous sections of wells and borings through the Superficial Deposits.

CHAPTER IV.

CONFIGURATION, STRUCTURE, AND LIMITS OF THE BASIN.

Configuration.

In the uncovered coalfield the plateau of Carboniferous rocks has been scooped out into broad and often deep valleys, round which the strata wind in tortuous outcrop. The more resistent rocks, such as the Millstone Grits and the sandstones of the Lower Coal Measures rise up in bold relief; but the landscape is not so strongly featured when sculptured out of the Middle Coal Measures, though these have been channelled into the valleys of the Erewash, Rother, Don, Calder and Aire.

Most, if not all of the denudation, is of comparatively recent date, and much of it is probably newer than the Glacial Epoch. The plateau slopes as a whole to the east up to the escarpment of the Magnesian Limestone. Where the escarpment is breached by valleys and the Coal Measures are exposed, it is found that the Permian deposits everywhere rest on an even surface of the Carboniferous rocks, suggesting that the configuration of the coalfield under the Permian will not present the rugged outline of the exposed coalfield.

Between Nottingham and Thorne a sufficient number of shafts and borings have reached the Coal Measures to enable the construction of a rough outline map, showing the contours of the surface of the concealed Carboniferous plateau over the central part of the coalfield (Plate I.). Each of the contour lines is obtained by taking the depth to the Coal Measures at three points arranged triangularly. It is assumed that between two of these points the inclination of the Coal Measure surface remains uniform, so that if the line joining two points is subdivided into equal lengths these will give the depth to the Coal Measures at intervals between the two known points. A second side of the triangle is subdivided in the like manner, and the points giving equal depths to the Coal Measures are then joined. The same process is repeated for the rest of the area.

The method supposes the absence of extensive post-Permian faulting. Between Nottingham and the Yorkshire border the recent survey on the six-inch scale has shown the general absence of faulting in the newer formations. South of Nottingham there are several large faults affecting the Trias, and it has not been thought advisable to continue the contour lines south of the Trent. Near Doncaster the swerving of the contour lines may be caused by the presence of faults which are known to displace the Permian rocks to the west at Conisborough. The contours are not extended north of Thorne, since the Triassic rocks are here concealed under the Superficial Deposits and there are only a few borings which reach Coal Measures.

While the parallelism of the contour lines is probably not so exact as represented, it shows a striking uniformity in the slope

of the Coal Measure surface underneath the Permian and Trias. The map it is hoped will afford therefore a ready means to obtain the approximate depth to the Coal Measures in future explorations.

The slope of the buried surface is directed a few points north-of-east, and is, therefore, oblique to the north-west strike of the Coal Measures. Its amount varies between 90 and 100 feet per mile, or about one degree, which is less than the general dip of the Coal Measures towards their outcrop. Higher Coal Measures, therefore, occur more frequently beneath the Permian than at the outcrop. In some cases the dip is the same, and a shaft near the outcrop reaches Coal Measures at nearly the same horizon as one situated in the direction of full dip. In this case the horizontal shift of the outcrop of a bed by a fault of even small throw is considerable, so that another shaft placed on the line of strike may enter Coal Measures at a different horizon. From evidence obtained at Kelham and Thorne it appears that the Coal Measures, at least locally, rise to the east on approaching the Trent, so that the base of the Permian rests on lower horizons in the Coal Measure sequence, and if the plane of the pre-Permian denudation continues the whole of the Coal Measures will ultimately be cut out by the newer formations (Fig. 3, p. 45).

Structure.

Three widely separated periods can be recognised during which the main structural features of the coalfield were formed. Some of these were faintly outlined during the deposition of the Carboniferous rocks; others were added and older ones modified in post-Triassic and possibly in Tertiary times, but the main structures originated and were stereotyped during the long interval which elapsed between the close of the Carboniferous and the opening of the Magnesian Limestone period. The recognition of these three stages in the geological history of the coalfield, and of the relative extent of the deformation of the Carboniferous strata attributable to each, constitute an important branch of investigation applicable not only to the present area but to all the coalfields of Carboniferous age in western Europe.

The disturbances may be considered in the consecutive order of their occurrence as (1) those of Carboniferous age; (2) those of post-Carboniferous but of pre-Permian age; and (3) those of post-Permian age.

(1) *Carboniferous movements.*—The marked palæontological break between the Upper and Lower Carboniferous rocks does not appear to have been accompanied by a stratigraphical discordance in the present area, at any rate there are no evidences of an unconformity between the Millstone Grits and the Limestone Shales.

Among the Upper Carboniferous rocks the frequent alternation of marine, estuarine, and, in the case of the seams of coal possibly terrestrial conditions, indicates repeated changes in level. Though oscillatory movements are thus clearly demonstrable there are no proofs that they were accompanied by contemporaneous folding and extensive fracturing or of much erosion

of the rocks. But while the structural changes were of small account, the effect of the oscillatory movements on the sedimentation of the Coal Measures was considerable. The Coal Measures, it is agreed, consist of shallow water deposits. It is therefore impossible to account for the much greater accumulation of sediments over the central part of the coalfield other than by differential movements acting during their deposition.

In an area undergoing differential movement it may be expected that the sediments would be raised locally above sea-level and subjected to erosion. The well-known "washouts" met with in the Top Hard (Barnsley) Seam, in the Deep Hard (Parkgate) Seam and in other coals, furnish examples of contemporaneous erosion on a small scale. The removal of the coal is usually attributed to the action of streams flowing across the areas of Coal Measures. A tidal scour, however, would produce the same result. A more convincing example of inter-Carboniferous denudation accompanied by elevation is the occurrence of angular and rounded fragments of coal at several horizons in the Middle Coal Measures.[1] These pieces of hard coal show that some of the lower seams had been consolidated and then denuded before the later sediments were deposited. Considering the friable nature of coal its presence in the form of fragments is in favour of a slight temporary elevation of the low-lying margins of the area of deposition rather than of considerable and prolonged emergence. The orderly sequence in which the groups and sub-groups of the Coal Measures follow each other from one end of the coalfield to the other precludes extensive contemporaneous denudation, which, indeed, has been advanced only in the case of the alleged unconformity of the Rotherham Red Rock.

The greater part of the folding and faulting of the Coal Measures is certainly later than the formation of the Upper Coal Measures; but in one district of the Whitwood Colliery it is stated by Professor Kendall[2] that a "small fault throws a coal-seam to the extent of sixty feet, and does not affect a seam above it." This is an exceptional occurrence unless the phenomenon has been undetected in other collieries.

(2) *Post-Carboniferous and pre-Permian movements.*—Throughout the Carboniferous period depression and deposition were practically continuous. At its close a reversal of movement set in: elevation succeeded depression; denudation, on a vast scale, followed deposition. When, at the commencement of the Magnesian Limestone Epoch, depression and sedimentation again took place, the complicated structure of the coalfield and its outline had been almost completed while thousands of feet of Carboniferous rocks had been swept away.

The disturbing force in the form of a lateral thrust which buckled up the originally horizontal or gently dipping Coal

[1] The Haigh Moor Coal in many pits within ten or fifteen miles of Normanton affords a good example of a wash-out with the formation of a conglomerate, containing pebbles of coal, which fills up the hollows in the denuded parts of the seam (P. F. Kendall) 'The Geology of the Districts around Settle and Harrogate.' *Proc. Geol. Assoc.*, pt. 1, vol. xxii, 1911, p. 44.

[2] *Ibid.*, p. 44.

Measures appears to have come from two directions. By far the most powerful thrust came from the east. It was accompanied, or, according to some authorities, it was preceded by a secondary impulse from the south and south-east. Whether the compressing forces are regarded as acting together or separately, they bent the horizontal or gently inclined sheet of Carboniferous rocks into a series of ridges (anticlines) and basins (synclines). One of these main ridges is occupied by the limestone country of Derbyshire; the chief basin is filled with the Coal Measures. While the relative age of the movements is disputed, it is quite certain that the two sets operated and were completed before the Magnesian Limestone period, for the Permian rocks, gently inclined, pass over the edges of the anticlines and synclines without themselves being folded; also, as happens north of Leeds, they are sometimes inclined at a right angle to the underlying Carboniferons rocks.

It is important to bear in mind that the impulse from the east was the most intense and that to it is due the elongated north and south direction of the coalfield. At the southern end of the coalfield, east of the Erewash Valley, it mastered the movement from the south, so that the east-and-west trend of the Coal Measures between Dale and Sandiacre is twisted round to the south-east in which direction it is known that it extends past Ruddington and for many miles to the south-east. If the thrust from the south had dominated the one from the east, then, as was once thought, the coalfield would have terminated a few miles south of Nottingham City. According to Clifton Ward, the east-and-west fold at the northern end of the coalfield is similarly turned to the north-east; but Professor Kendall considers that it continues, without deflection, under the Permian and Trias eastwards to the Chalk escarpment (p. 46).

Folds represent only one way in which rocks subjected to pressure accommodate themselves so as to occupy a confined space. The same result is obtained by the displacement of the strata by faults, of which the visible coalfield affords numerous examples.

The faults belong to two systems. One trends north-west or north-and-south, being roughly in the direction of the major folding. The other, represented by several faults, crosses the coalfield in a north-easterly direction. A few faults have the direction of the east-and-west folds, of which one, the Clifton Fault, at the southern end of the coalfield, is entirely of post-Triassic age.

Several of the faults belonging to the north-west and north-east systems can be traced up to the escarpment of the Magnesian Limestone which either extends in unbroken continuity across the faulted Coal Measures, or the displacement of the limestone is very much less than that of the Coal Measures. In the first case the faulting was certainly older than the Magnesian Limestone; and in the second, the maximum displacement evidently took place previously to the deposition of the limestone.

Many of these faults have been proved in the underground workings beneath the Magnesian Limestone, and others are met

with which do not extend into the visible coalfield, or affect the overlying Permian and Trias. In the south, at Bulwell, a fault trending a little south of east, has been proved to have a throw of 261 feet in the workings of the Cinderhill Colliery. In the quarried Permian limestone and Triassic sandstones at the surface it has only a few feet throw. On the same line a belt of faulting extends across Nottingham city, and may indicate the surface position of faults having a much greater displacement in the Coal Measures. Their existence is at least sufficient to invalidate the calculation of the dip of the Top Hard Coal as deduced from its depth in the shafts of the Clifton and Gedling collieries.

Further north the Magnesian Limestone is not affected by a belt of faults, having an aggregate downthrow south, which crosses the Derbyshire Coalfield from north-west to south-east between Chesterfield and the Limestone escarpment west of Skegby. As the faulted belt keeps roughly parallel with the pronounced anticline (Brimington anticline) which extends from near Holmesfield to Teversall, it may continue further to the south-east, in which case it would pass between the borings at Oxton and Thurgarton and that of Kelham and so bring the Middle Coal Measures nearer to the surface on the upthrow side of the fault. The faulted Dronfield syncline which succeeds the Brimington anticline on the north is also in alignment with disturbances found in working the Top Hard Coal beneath the unfaulted Magnesian Limestone between Langwith and Whitwell.

Travelling north, the next conspicuous belt of fracture belongs to the north-east system of faulting. This consists of the remarkable disturbances which range along the Don Valley between Sheffield and the Magnesian Limestone outcrop near Conisborough. Green states that 'between these faults the beds are twisted round so as to range in a north-easterly and south-westerly direction with a dip to the south-east, whereas the average strike of the adjoining country on either side of the faults is north-west and south-east, and the dip to the north-east.'[1]

If the line of this faulting is continued to the north-east of Conisborough it passes between Bentley Colliery (p. 65), where the Barnsley Coal lies 1,847 feet below sea-level, and the boring at Armthorpe (p. 63) in which, though it is nearly on a level course with Bentley Colliery, the Barnsley Coal is certainly at a much greater depth. Proofs of the extension of the Don faults beneath the superficial deposits to the north-east of Armthorpe are entirely wanting. The possible presence of this pronounced disturbance in the deeper parts of the syncline should however be kept in mind. It is certainly not safe to assume that the depth to the Barnsley Coal at Hatfield is intermediate between the depth (3,115 feet) of this seam at Haxey and that of the Thorne Boring (2,736 feet).

North of the Don Valley several faults with a north-easterly direction and having considerable throws, extend up to the Magnesian Limestone; but there are no proofs of their prolongation into the concealed coalfield, though the boring at Barlow

[1] 'Geology of the Yorkshire Coalfield,' *Mem. Geol. Surv.*, 1878, p. 488.

(p. 66) passed through highly inclined and faulted Middle Coal Measures. The boring is on a line with the faults seen at Pontefract, 12 miles to the south-west of Barlow, but a slight change in their direction would carry them either to the north or to the south of the boring.

The close association of faulting and folding exemplified by the faults accompanying the Brimington anticline is repeated in several other cases, notably by the faults bounding the anticline along the Erewash Valley between Trowell and Langley Mills, and by those limiting the Shipley syncline. The change in the strike of the Coal Measures between the Don faults also suggests the partial formation of a pre-Permian anticlinal fold, in which the strata became dislocated before the completion of the fold.

The disturbances found in the exposed coalfield, although numerous, are not so abundant or so intense as those in the coalfields on the west side of the Pennines. The folds are less acute: the faults of inferior magnitude. It is perhaps too generally assumed that the concealed coalfield was even less influenced by the pre-Permian movements than the visible coalfield, a conclusion in many cases deduced from the comparative absence of faults in the Permian and Trias. The examples previously given of the Magnesian Limestone resting undisturbed on faulted and folded Coal Measures clearly show that the structure of the coalfield underneath the undisturbed Permian and Triassic rocks may be often of a complex character. A case is on record where the depth to the Barnsley Coal was 300 yards shallower than the depth estimated from the dip in the nearest workings.

Post-Triassic movements.—At the southern end of the Derbyshire Coalfield the Millstone Grits and Lower Coal Measures between Morley and Sandiacre are inclined to the north at a high angle. The Triassic sandstones on the contrary dip at a very gentle angle to the south. The movement which caused the fold in the Carboniferous rocks is here certainly of pre-Triassic age. The Cinderhill Fault previously mentioned (p. 39) was also mainly pre-Triassic. It is evident, however, that at the southern end of the coalfield some of the faulting is later than the Keuper Marl. In Cut Through Lane, east of Lenton Hall, a fault brings Keuper Marl against the lower portion of the Bunter Pebble Beds. A little farther east, in the river bluff north of Tottle Brook, Keuper Waterstones have been brought in touch with the Lower Mottled Sandstone. The fault has, therefore, a throw of between 240 to 270 feet in the Trias. In the workings of Clifton Colliery this fault has a throw of 285 feet in the Coal Measures. It is therefore mainly if not entirely newer than the Keuper Marl. To the south a second fault of 153 feet throw in the Deep Hard Coal of Clifton appears to affect the Trias to the same or possibly larger amount since, south of Lenton Hall, it brings Keuper Marl against Lower Mottled Sandstone.

In tracing the outcrop of the Trias formation between Nottingham and Retford though some faults are met with, none of them possess a throw of more than a few yards. North of Retford the outcrop of the Triassic rocks is hidden under alluvium and warp, and it is not known to what extent they are faulted.

The post-Triassic disturbances, as shown by faulting, are therefore of much less magnitude than those of pre-Permian date; and so far as is known the chief post-Triassic faults are confined to the southern part of the basin. The small faults affecting the Trias between Nottingham and Retford, may, as in the case of the Cinderhill faults, indicate the surface position of much larger dislocations in the Coal Measures.

Gentle undulations of the strata occur among the Triassic rocks; and between Bulwell and Linby a narrow monoclinal fold in the Magnesian Limestone coincides with several faults of small throw, and of considerable linear extension in the Coal Measures. With this exception, sharp folds, extending in belts for considerable distances, are not met with in the Permian or Triassic formations. The gentle easterly inclination of the Permian and Triassic rocks indicates a slight upheaval, but as the dip of the Permian strata coincides very closely with the slope of their Carboniferous floor, and the deposits thicken in the same direction, it may in part represent planes of deposition.

Igneous rocks in the Coal Measures.—Possibly one of the latest signs of movement is afforded by the igneous rock of the Owthorpe and Kelham borings. There can be little doubt that this rock is intrusive into the Coal Measures, and though it has not been found to pierce the Triassic rocks, yet in its petrological character, (p. 58) it bears some resemblance to those igneous intrusions which traverse the later Triassic sediments in Staffordshire. At Whitwick in Leicestershire, however, it is thought that the 'whinstone' is of late Carboniferous age, and was injected in the upper part of the Coal Measures, being overlain by the highest of these measures, which were denuded prior to the deposition of the Trias.[1]

Limits of the Basin.

As previously mentioned (p. 37) the original sheet of horizontal or gently-inclined Coal Measures was compressed by the pre-Permian movements into an elongated basin of which one edge forms the boundary of the visible coalfield on the west; but the rest of the basin, except small parts of the northern and southern margins, is concealed under the Permian and Triassic formations.

The probable form and extent of the concealed part of the basin-fold was fully and critically discussed in a stimulating report by Professor P. F. Kendall.[2] Since 1905 much additional information has been obtained from the borings described in this memoir, and it is now intended to state how far the boundaries of the concealed areas suggested by Professor Kendall are confirmed or modified by these later explorations.

Southern boundary.—On the map accompanying the Report of 1905, the southern limit of the coalfield, as considered by Professor Kendall, is indicated by a line extending from the outcrop

[1] Fox-Strangways 'Leicestershire and South Derbyshire Coalfield,' *Mem. Geol. Surv.*, 1907, p. 33.

[2] 'Final Report of the Royal Commission on Coal Supplies,' pt. ix, 1905, pp. 18–35, with plates.

of the Millstone Grits west of the Erewash Valley to within five miles south of the boring at Ruddington, and is thence continued to the south-east for many miles to the borders of the Fen Country. This extension was regarded by the Commissioners (*op. cit.*, p. 3) as 'too hypothetical' and the limit was fixed at an east and west line, drawn about two miles south of the Owthorpe Boring.

At this date the boring at Clipston had not been commenced; and of the section of Coal Measures proved at Owthorpe only the first 244 feet had been made public. It has been previously stated (p. 7) that the increased thickness of the Millstone Grits in the Ruddington Boring as compared with their development in the Derwent Valley supports the view of their further extension to the south-east, and that the Carboniferous formation is not dying away south as it is at the northern end of the Leicestershire Coalfield.

The thickness of Coal Measures proved at Owthorpe amounted to 963 feet. Several coals exceeding two feet in thickness were passed through and one near the bottom is recorded as being 4 feet 8 inches thick. An examination of the cores showed that the rocks belong to the Middle Coal Measures and that, if not horizontal, the inclination was very slight. Unless the measures turn up sharply to the south, the southern limit will therefore extend some distance beyond the limit assigned in the Report.

In the boring at Clipston the inclination of the Coal Measures was also very slight and since 1,135 feet of Coal Measures were proved in the boring, the southern limit of the coalfield would approximate, if it does not actually coincide, with that adopted by Professor Kendall for this part of the area.

The coalfield, therefore, extends for some distance south of Owthorpe, but without further data it is not possible to fix its southern boundary except on the general lines suggested by Professor Kendall.

Northern Boundary.—On the northern margin of the visible coalfield, the Coal Measures, as previously stated (p. 38), rise against an anticline which brings the Millstone Grits to the surface. This anticline, of which the axis is directed nearly due east, can be traced along the valley of the Wharfe up to the outcrop of the discordant Magnesian Limestone. Inliers of Millstone Grits occur east of Thorner, and, on the evidence obtained in a boring, they are considered to extend immediately beneath the Magnesian Limestone to near Tadcaster; but to the east of Tadcaster all traces of the solid formations are lost sight of beneath the Drift and Alluvium of the Vale of York and though a few borings have reached Triassic rocks they have not penetrated the Bunter division.

The Wharfe anticline, if it extends across the Vale of York, would form the northern boundary of the concealed coalfield. According to Clifton Ward (Report of the Commissioners relating to Coal, 1871, pp. 505-07) it does not; while Professor Kendall considers that it does form a boundary.

Clifton Ward based his contention on the structure of the exposed Carboniferous rocks between the Wharfe and Harrogate. In his evidence he stated that "the general dip of the Millstone

Grit beds is not south but east or north, or something between them. Nor is there, as far as I have seen at present, anything like a great axis of the older Limestone rocks coming across the Millstone Grit Series and abutting against the Magnesian Limestone." After noting that the principal direction of the main faults was along the northern margin of the coalfield he continued by pointing out that "in the neighbourhood of Leeds there is a band of large faults running north-east and south-west, almost precisely in the direction of the Harrogate anticlinal." From this he inferred that the continuation of the Yorkshire Coalfield will also be in a north-easterly direction. The alteration in the strike of the Carboniferous rocks is, he suggested, comparable with that accompanying the Don faults. It may here be added that at the southern end of the Derbyshire Coalfield a parallel instance of the deflection of an east-and-west fold has been previously cited (p. 38).

The dissentient opinion of Professor Kendall depends upon the significance to be attached to the structures observable in the Jurassic rocks around Market Weighton on the east side of the Vale of York. With regard to the Wharfe anticline he remarks (*op. cit.*, p. 28) that "if the assumed axis of the fold and the actual boundary of the Coal Measures be projected forward, they strike the Chalk Wolds on the crown of one of the most remarkable anticlines in the whole country . . . the first fact which will arrest attention when the strata at the fold of the Wolds escarpment are examined is the enormous hiatus in the Secondary Series, the chalk resting directly on the Lower Lias, so that the whole of the Neocomian Series, the Oolites, and the Upper, Middle and a portion of the Lower Lias are missing." After a critical discussion of the evidence Professor Kendall concludes (p. 30) "The facts and arguments which I have stated seem to me to point conclusively to the occurrence of an anticline of pre-Permian date extending across the Vale of York and forming the northern boundary of the coalfield." He therefore considers that the northern limit of the coalfield lies about four miles north of the recent boring at Selby. At the site of this boring (p. 67) 3,000 feet of Coal Measures are estimated to exist between the Magnesian Limestone and the Millstone Grits. Therefore to allow the Millstone Grits to abut against the Magnesian Limestone four miles north of Selby they must rise at the rate of 1 in 7 (8 degrees). But at Selby the Coal Measures are nearly if not quite horizontal. Thus, unless they turn up rapidly they will stretch beyond the projected line of the Wharfe axis.

At Selby the evidence for or against an easterly extension of the Wharfe anticline is not conclusive; but whatever significance is to be attached to the hiatus in the later Mesozoic rocks near Market Weighton, the increase in the thickness of the Permian rocks in the boring compared with that at Carlton and Thorne, their gentle inclination both in the boring and along the outcrop where it crosses the Wharfe anticline, show, that they at any rate were not influenced by the later elevatory movements. The main structures of the coalfield, as before insisted on (p. 36) originated and were stereotyped before the commencement of the

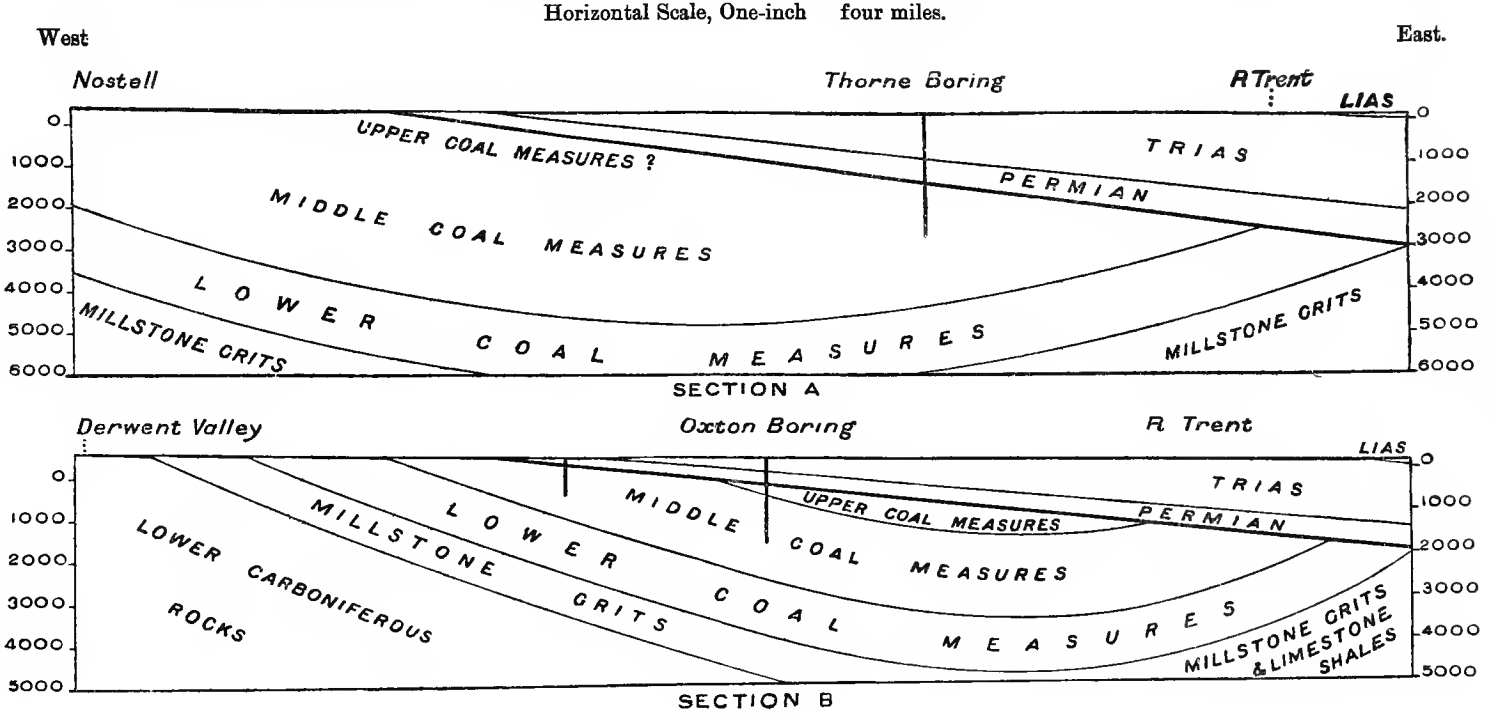
Magnesian Limestone period, and if sometimes modified, they were never much affected by the post-Permian disturbances.

Since the slightly older or simultaneously-formed east-and-west fold has in many cases been deflected by the north-and-south (Pennine) disturbance it is possible, as suggested by Clifton Ward, that the Coal Measures extend across the Vale of York in a north-easterly direction. The evidence of the Selby Boring certainly favours this suggestion; but it is not directly opposed to the extension of the Wharfe anticline eastward beneath the concealed outcrops of the Permian and Triassic rocks. It is however evident that the revival of the elevatory movement did not take place until comparatively late Mesozoic times since the Permian and Triassic rocks were not affected by it; nor was the uplift accompanied by the powerful folding and faulting of the strata which gave the coalfield its main structural outline. The alignment of the Market Weighton disturbance with the Wharfe anticline is certainly remarkable, and indicates a much later renewal of a movement having the same direction as that of pre-Permian date. But there is this difference; the Market Weighton anticline did not come under the influence of a powerful impluse from the east, which was the stronger and determining factor in post-Carboniferous but pre-Permian times. The northern boundary of the coalfield therefore depends on whether the Wharfe anticline is or is not deflected to the north-east by the Pennine movement.

The Eastern Boundary.—The Report for 1871 places the boundary of the concealed coalfield at two or three miles east of the Trent. This boundary line runs parallel to the river between Nottingham and Amcott and roughly coincides with the outcrop of the Lower Lias. In the later Report (1905) it is suggested that the margin lies near the outcrop of the Lower Cretaceous rocks, 20 to 30 miles east of the Trent.

Both opinions were based on broad generalisations: the smaller extension was suggested by Green on the supposition that the concealed area approached in size that of the visible coalfield; the liberal increase alloted by Professor Kendall and accepted by the Commissioners (*op. cit.* p. 3) in 1905 was granted partly on the interpretation of the evidence afforded by the Coal Measure sequence in the borings at Thurgarton, South Scarle, and Haxey, but particularly on the supposition that folds in the newer formations indicate the position of folds in the Carboniferous rocks. Since 1905 the evidence obtained in a boring near Kelham, 1½ miles west of Newark, shows that the limit assigned in 1871 is nearer the truth in the south; while the depth to the Barnsley Coal in the boring at Thorne, 11 miles north-east of Doncaster does not favour an extension of the coalfield for more than a few miles east of the Trent in the north. In Nottinghamshire at any rate, and probably in South Yorkshire, a great reduction must be made in the estimates of 1905. A possibility of a reduction in the estimates was indeed implied in the following qualifying statement by the Geological Committee:—"With regard to the eastern extension of the coalfield advocated by Professor Kendall,

FIG. 3.—*Diagrammatic Sections to illustrate the probable structure of the Coalfield in the North (A) and in the South (B).*



though we feel some reluctance to admit so large an increase in our estimates for ground of which so little is known, we admit that the eastern limit as drawn by him is the only line for which evidence exists and we therefore accept it" (*op. cit.*, p. 3).

The eastern boundary suggested by Professor Kendall is drawn at a line about six miles from the axis of an anticline which, extending in a north-easterly direction, affects the Chalk and Lower Cretaceous rocks from the Wash through Willoughby and Alford to Louth. On cumulative, rather than on any positive evidence, this anticline is regarded as a posthumous fold repeated upon a crest in the deep-seated Carboniferous rocks. On this interpretation it is considered that the Lower Coal Measures rise to the east and abut against the newer formations near Tealby, about 20 miles east of the Trent. An alternative view is expressed (*op. cit.*, pp. 20 and 31) that the fold in the Carboniferous rocks is not a posthumous one and the Coal Measures may extend to and beyond the coast of Lincolnshire.

The axis of the supposed fold in the Carboniferous rocks is considered by Professor Kendall to lie (*op. cit.*, p. 31-2) between Haxey and Arksey (Bentley) and a "good deal to the east of South Scarle." The Thorne Boring is therefore situated near to or on the assumed axis: Kelham lies 12 miles south-west of Scarle.

Since in the Thurgarton Boring 5½ miles south-west of Kelham, the Magnesian Limestone rests on a considerable thickness (524 feet) of Upper Coal Measures, at Kelham a greater, and at Scarle a still greater amount should occur, unless the measures flatten very rapidly on approaching the supposed axis. However at Kelham the Magnesian Limestone rests on Middle Coal Measures. It appears, therefore, that the axis of the syncline instead of lying to the east of South Scarle is situated to the west of Kelham and possibly a little west of Thurgarton.

To bring the Lower Coal Measures into their position at Kelham the measures must rise to the north-east of Thurgarton at the rate of 1 in 15 (4 degrees). The same rate and direction brings the Lower Coal Measures against the Magnesian Limestone at South Scarle.

As the Carboniferous floor of the Permian rocks slopes east at the rate of 1 in 57 (p. 36) between Kelham and South Scarle, it follows that the margin of the basin is reached within a mile or two east of Kelham; and that if Upper Coal Measures are present at South Scarle they are introduced by another fold between which and the extension of the Nottinghamshire Coalfield there intervenes a tract of Millstone Grits or of Lower Carboniferous rocks. It is possible that Kelham lies on the upthrow of a large fault and that a large downthrow fault may exist between it and South Scarle. This does not affect the general conclusion that to the north-east of Thurgarton the Coal Measures do not extend uninterruptedly with a gentle fall to and beyond South Scarle in the direction of the Willoughby-Louth anticline, but they were affected by one, and possibly more than one, powerful disturbance of which the newer formations do not show any indication either in the form of folding or faulting.

In the Thorne Boring the Barnsley Coal was penetrated at a depth of 2,736 feet below ordnance datum, or 885 feet lower than in the shafts of Bentley Colliery, 10 miles to the south-west. This is considerably less than the depth would be if calculated from the dip of two degrees observable in the workings of Bentley Colliery. The dip either decreases rapidly north-east of Bentley until the beds are horizontal, or the dip gradually diminishes and the strata rise in the direction of Thorne (Fig. 3, Sect. A, p. 45).

After a correction was made for a deviation of the hole from verticality, a dip of two to three degrees was observed in the cores at Thorne. Its direction was not ascertained, but the fact of the measures being inclined at all suggests that the axis of the basin lies between Bentley and Thorne and the measures are rising to east. If the rise amounts to only two degrees, and on the assumption that the Permian rocks descend at the same rate east of Thorne as they do to the west, a boring situated near the Trent at Amcott, 10 miles east of Thorne, would reach the Coal Measures at about 1,700 feet below the Barnsley Coal, and the Millstone Grits would rise against the Magnesian Limestone within one and two miles east of the Trent (Fig. 3, Sect. A, p. 45). A boring near Crosby, one mile south-east of Amcott, and in which it has been stated[1] Coal Measures were reached, should go far to prove the position of the eastern margin of the coalfield as suggested by the evidence of the Thorne Boring.

[1] *Rep. Brit. Assoc.* for 1910 (1911), Sheffield Meeting, p. 609.

CHAPTER V.

SHAFT-SECTIONS AND BORINGS.

The sites of the shafts and borings have been chosen generally with a view of exporting the coal. South of Nottingham several attempts have been made to find workable seams on the route nearest to London; in a central region, between Nottingham and Gainsborough, a large area has been proved by shafts along the western margin of the concealed coalfield, and by borings near the navigable Trent; but the most active development is found in the north, around Doncaster, where transit by rail and water especially favours an export trade. For this reason, though the concealed coalfield forms really one geographical and geological region, the explorations are described under three districts.

It is necessary to exercise some caution in placing a too literal interpretation on the records. In those of shaft-sections the description of the rocks, when left to the master-sinker, is often misleading. The thicknesses of coals are usually measured with accuracy and their plumbed depths ascertained; but the description of the rocks is frequently incorrect. Thus, the word ' clunch ' is used for strata of very varied composition—for a soft shale, marl, fireclay, and even for a sandstone if it happens to be of a somewhat incoherent character and, therefore, easily drilled.

In the records of borings the same confusion exists and rocks of a totally different character are entered under the same name. In addition to this, the thickness of the strata bored through, since it is taken from the length of the boring rods, will, when the boring departs from verticality, be in excess of the true thickness. A slanting hole also gives a false dip to horizontal strata, and a low dip to inclined beds. As a rule there is little deviation from plumb-line in boring through the Permian and Triassic rocks, but in Coal Measures at Barlow (p. 66) the line of the hole was inclined at about 15 degrees; at the Thorne Boring (p. 66) also there was a considerable deviation. To what extent the rotatory drill records faithfully the thickness of soft coals and whether in some cases seams are not passed through without being noticed remains uncertain, but some of the borings suggest such a possibility.

1. Southern District.

This includes an area situated south of the Trent between Bottesford and Nottingham on the north, and Belvoir Castle and Ruddington on the south. It amounts to about 100 square miles, occurring in the one-inch Geological Survey Maps, Sheets 126 and 142, New Series.

Cover.—The cover of the Carboniferous formation consists of the Trias over the west and central parts, succeeded by the Lias in the south and east. The Permian formation may be represented by the conglomerate in borings at Clipston and Owthorpe, and may possibly occur in the eastern part of the area. The

complete Triassic sequence has been proved only at Owthorpe. The character of the rocks, except for about 150 ft. of the top beds, is given by the boring at Clipston (p. 84), where the sequence can be taken as typical for the whole area. The subdivision of the Keuper Waterstones graduates upwards into the Keuper Marl, but its base is indicated by red and grey sandy marls, and at Ruddington by a conglomerate three feet thick. The Bunter formation shows an expansion eastward from 220 ft. at Ruddington to 274 ft. at Owthorpe.

Carboniferous rocks.—At Ruddington the Trias rests on Lower Coal Measures below the horizon of the Kilburn Coal. The boring also proved a considerable thickness of Millstone Grits and thus indicates the western margin of the coalfield. At Clipston, Owthorpe and Edwalton, a considerable thickness of Middle Coal Measures is present; but the coals passed through cannot be satisfactorily correlated with those of the Derbyshire sequence or with those at Clifton Colliery, in which the Top Hard Coal (5 ft. 11 in. thick), the Deep Soft Coal (5 ft. thick), and the Deep Hard Coal (5 ft. 7 in. thick), are thicker than at Radford in the Leen Valley to the North.

The measures are inclined at a gentle angle a few points east of north.

Owthorpe Boring.

(Fig. 4, p. 50, and Section No. 16, Appendix, p. 108.)

The Secondary rocks in which the boring commenced were drilled on the flat-rope system, and samples of the cores only have been preserved; but those of the Coal Measures obtained by the diamond drill have been carefully kept and were examined by us. It is impossible to give the exact horizon to which the red strata at the top of the Coal Measures belong. The marine horizon commencing at a depth of 1,572 ft., is either the one 300 ft. above the Deep Hard Coal, in which case the red strata are stained Middle Coal Measures; or it is the one above the Clowne Coal, so that the red measures may belong to the Etruria Marls. On the latter interpretation the coal, 4 ft. 8 in. thick at 2,012 ft. in depth, would agree in position with the Top Hard. The evidence for the identification of the marine band with one of those in the Middle Coal Measures is, however, not sufficient to settle decisively the question; but, obviously, it is not the marine bed forming the roof of the Alton Coal, for in this case the Millstone Grits would have been entered below the depth of 1,750 ft.[1]

Clipston Boring.

(Fig. 4, p. 50, and Section No. 8, Appendix, p. 84.)

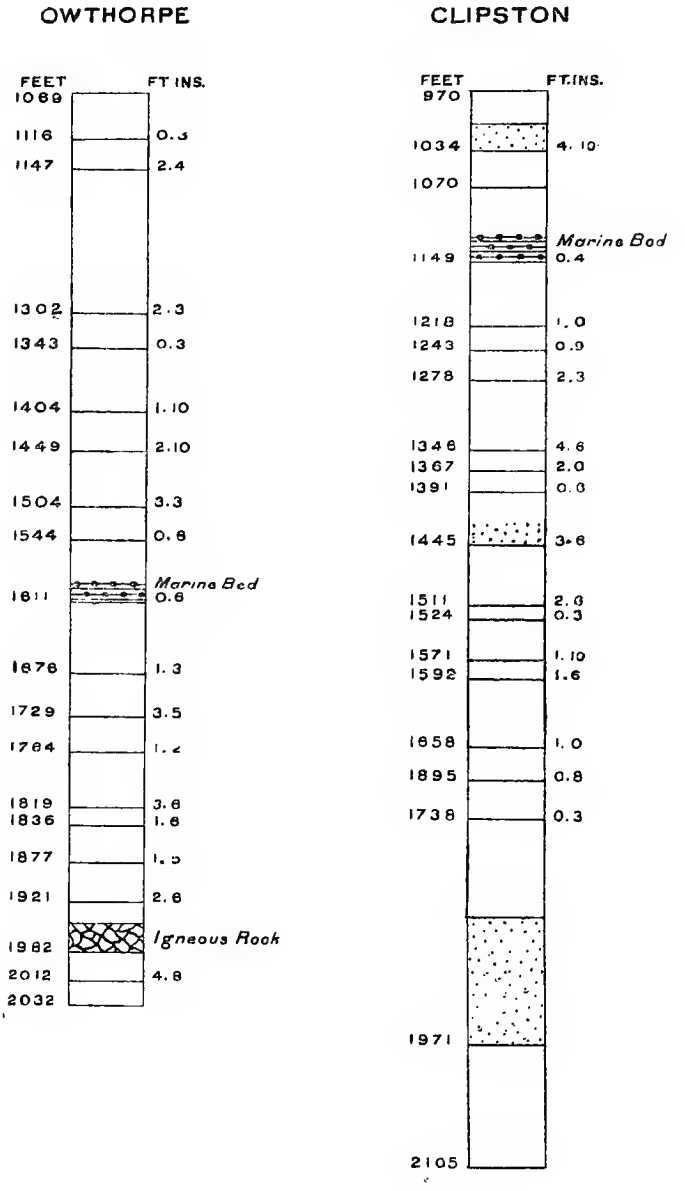
This boring lies two miles west of Owthorpe.

The cores of the Triassic rocks were examined by Mr. B. Smith, who furnishes the following account:—

The boring was commenced near the base of the Tea-green Marl, and the first core was extracted from a depth of 57 ft.

[1] A fuller account of this boring and a description of the igneous rock is given in the 'Memoir on the Geology of Newark and Nottingham,' *Mem. Geol. Surv.*, 1908, pp. 18, 19.

FIG. 4.—*Sections illustrating the Coal Measures below the Trias at Owthorpe and Clipston.*



Scale; *One Inch = 200 Ft.*

Numbers on left in both sections give depths from surface ; those on right the thickness of coals. Sandstones shewn by stippling.

The five bands of gypsum, below this level, were white, saccharoidal and semi-translucent, and varied from 6 ins. to 8 ins. in thickness. They represent the valuable gypsiferous horizon worked at Cropwell Bishop. At lower depths the marls were frequently riddled with veins and nodules of gypsum, which rendered the cores somewhat like marble in appearance.

Above a depth of 240 ft. the sandstones (and grey rock) were coarse-grained skerries, chiefly composed of quartz grains; whereas those below this depth, in the lower part of the Keuper Marl were, as a rule, of finer grain and probably consisted to a large extent of dolomite.

The Keuper Waterstones, as elsewhere (p. 31), were not clearly separable from the Keuper Marl. Some of the harder sandstones were as much as 3 ft. in thickness and grey in colour, but the majority were red and occurred at a low horizon. The basal beds of the usual Nottinghamshire type (p. 31), comprised alternations of red and grey micaceous ripple-marked sandstones, shales, and marls, with a very thin layer of angular quartzitic pebbles in a green marly sandstone at the base.

The Bunter consisted of red and grey sandstones with scattered quartzitic pebbles and a few layers and lumps of marl. Beds of conglomerate occurred at 739 and 760 ft. depth. At lower levels the sandstone was of a finer texture, but still contained a few pebbles and marl pellets. The conglomerate at 960 ft. was separated by sandstone into two portions, the lower, about 6 ft. 6 in. in thickness, being very coarse at the base, where it consists of angular and sub-angular stones, up to 6 in. in length, embedded in a sandy matrix. Amongst the stones there were blue limestones and pale flinty cherts, red and yellow sandstones, pieces of marl or marly sandstone, and small ochreous pebbles.

Among the Coal Measures entered beneath the Trias there is the same difficulty as at Owthorpe in assigning them a definite position in the sequence.

The character of the rocks and the presence of several seams of coal indicate that the measures between 970 ft. and 1,592 ft. are Middle Coal Measures, while the absence of coals and the general character of the rocks below 1,592 ft. is rather suggestive of Lower Coal Measures. The sandstone commencing at 1,839 ft. depth resembles the Wingfield Flagstones of Ruddington, but if it belongs to this horizon there is a great difficulty in correlating the coals above 1,592 ft. with those of Derbyshire.

There can be little doubt that the bed with marine shells resting on the thin coal at 1,149 ft. depth is the same as the band at 1,611 ft. of the Owthorpe section. The fauna consists of *Pterinopecten*, *Lingula*, and goniatites, but does not contain any of the forms characteristic of the Mansfield Marine Bed (p. 20) or of the shales 300 ft. above the Deep Hard Coal in the Clay Cross area. It is, therefore, uncertain if the boring entered Coal Measures above or below the Top Hard Coal.

The measures showed no appreciable dip, and there were no distinct signs of faulting.

Ruddington Boring.

(Fig. 1, p. 6, and Section No. 18, Appendix, p. 111.)

This boring is situated 4½ miles nearly due west of Clipston. There can be no doubt that it proved a Carboniferous sequence from about the lower half of the Wingfield Flagstones down to 109 ft. in the Third Millstone Grit (Kinderscout Grit). The identification of the coal at 1,072 ft. in depth with the Alton Coal is shown by its position above the Rough Rock and by the presence of *Pterinopecten papyraceus* in the roof shales as noted by Mr. R. D. Vernon.

The boring is, therefore, situated near the western margin of the coalfield; and, unless the beds turn over to the west, Coal Measures will not be found in the valley of the Soar.

The measures, in contact with the Triassic rocks, though low down in the Coal Measure sequence, are of a red colour, showing that it is due to staining derived from the overlying red rocks.

Edwalton Boring.

(Section No. 10, Appendix, p. 91.)

This boring was an attempt to prove the Top Hard Coal at a point 2¾ miles south-east of Clifton Colliery. A few only of the cores were available for inspection, and an examination failed to afford any satisfactory evidence by which the seams mentioned in the record could be identified with any certainty. According to Coke[1] the boring entered Coal Measures at a horizon a short distance above the Dunsil Coal and ended at the horizon of the Black Shale (Silkstone) Coal. The description of the rocks between the depths of 985 ft. and 1,057 ft., suggests the marine bed 300 ft. above the Deep Soft Coal in the Chesterfield district (p. 13). It is thought that below the Deep Soft Coal the boring passed through a fault which cut out the Deep Hard Coal.

Clifton Colliery.

(Section No. 7, Appendix, p. 83.)

The importance of this record consists in its giving the only section, south of the Trent, of the Top Hard Coal and the measures down to the Deep Hard Coal.

In the shafts and in the workings which extend south to Wilford Farm, the Top Hard, Deep Soft, and Deep Hard are not inferior in thickness to these seams in the Erewash Valley. There was, therefore, no reason to expect that the borings at Owthorpe and Clipston would fail to give three or more coals of workable thickness.

The shafts are placed on the upthrow side of the Clifton Fault, which accounts for the Top Hard Coal having been reached 288 ft. nearer the surface than in the preliminary boring at Wilford (*see* below). The general inclination of the seams is north-east, or the same as that observed in the Erewash Valley. Besides the fault of 95 yards there are several others crossing the measures in

[1] *Trans. Fed. Inst. Min. Eng.*, vol. xi, 1895–96, p. 340.

a general easterly direction, with an aggregate downthrow south. The existence of these faults prevents an attempt to identify the seams of the Edwalton Boring on a calculation based on the depth and inclination of the seams in the Clifton workings.

Wilford Boring.

This boring was put down previously to sinking at Clifton. It is situated on the downthrow side of the Clifton Fault and reached the Top Hard Coal at a depth of 498 ft. The boring proved:—Alluvium, 21 ft.; Keuper, 192 ft.; Bunter, 246 ft.; and Coal Measures down to the Top Hard Coal, 39 ft.

Highfield Boring, Beeston.

(Section No. 13, Appendix, p. 98.)

This boring, completed in 1874, lies close to the Midland Railway, $1\frac{1}{2}$ miles west-south-west of Clifton Colliery. The cores are not available. Coke[1] considered that the highest measures lie 208 ft. below the Top Hard Coal, which will agree with the depth to the Deep Soft Coal as recorded in the section.

Spinney Boring.

(Section No. 20, Appendix, p. 114.)

Like the Beeston and Wilford trial holes this boring was a preliminary test to prove the Coal Measures previous to sinking at Clifton. It is situated at the Brickyard Spinney, south of the Trent. The cores were not available for inspection; and as regards the Coal Measures, Coke was satisfied that the record "is misleading" (*op. cit.*, p. 339). The Coal Measures appear to have been reached at nearly the same depth as at Wilford, although the boring is situated on the upthrow side of a post-Triassic fault of 153 ft. throw, which crosses the Trias south of Wilford.

Chilwell Boring.

The site of the boring is stated (Plant MS.) to be in a field, Nos. 5, 718, 752 on the General Map, on the Estate of Thomas Broughton Charlton. This field appears to be one near the Midland Railway, about $\frac{1}{4}$ mile south-west of Beeston Station. The published record[2] gives the following details:—Alluvium, $13\frac{1}{2}$ ft.; Red marl and white saudstone, 167 ft.; Pebble Beds, 250 ft.; Soft sandstone, 33 ft.; Coal Measures, $876\frac{1}{2}$ ft. In the Plant MS. it is stated that four seams of coal, from 5 in. to 17 in. thick, were passed through.

2. Central District.

This area, about 500 square miles in extent, situated chiefly in Nottinghamshire, stretches westward, from the Trent between Nottingham and Gainsborough, to the outcrop of the Magnesian Limestone.

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[1] *Trans. Fed. Inst. Min. Eng.*, vol. xi, 1895–96, p. 339.
[2] *Rep. Brit. Assoc.*, 1890, p. 366.

The coal-workings are practically confined to the Top Hard Coal, which is raised by numerous pits extending in a long line from the outskirts of Nottingham City to Shireoaks. West of Nottingham, pits in the Leen Valley work the Deep Soft and Deep Hard coals; but to the north, where their value has been proved only in a few cases, these seams remain untouched. Most of the shafts commence in the Magnesian Limestone; but the shafts of Gedling Colliery start in Keuper Waterstones, and those of Mansfield and Manton collieries in Bunter Sandstone. Explorations through the Keuper Marl have been made by borings at Thurgarton and Kelham; another which has not yet reached the Carboniferous rocks is in progress at Cottam.

The western margin is included on the one-inch Geological Survey maps, Sheets 125,[1] 112,[2] 100,[2] New Series; the central parts northward to Bevercotes fall within Sheets 126,[1] 113,[1] New Series; and the district around Retford and Gainsborough occurs within the one-inch Geological Survey maps, Sheets 82 N.E., 83 N.W., Old Series.

Cover.—In contrast to their development in the area north of Retford, the Superficial deposits are here feebly represented, and the outcrops of the Permian and Triassic rocks, which extend in bands trending roughly north and south, can be readily traced across the district. Consequently, the horizon at which a boring or shaft commences can be ascertained from the Geological Maps. The total thickness of cover is shown by the contour lines on the map (Plate I.).

The increase in thickness of the Permian rocks from south to north and from west to east, mentioned in a previous chapter (p. 27), is illustrated by all the sinkings and borings. Thus at Gedling Colliery the Permian consists of less than 50 ft. of limestone, marl, and shales, which at Manton Colliery, 21 miles north of Gedling, reach a combined thickness of 407 ft.; while 184 ft. of Permian strata at Mansfield Colliery has swelled out to a thickness of 500 ft. at South Scarle, 17 miles to the east. Each of the sub-divisions share in the expansion, though it is more marked in the Lower Limestone.

A northerly increase in the thickness of the Bunter Sandstone is shown by its expansion from 385 ft. at Gedling to 681 ft. at Bevercotes.

The porous Bunter Sandstones, owing to their broad outcrop, contain large volumes of water which in the pumping shaft of Manton Colliery amounted to 3,000,000 gallons per day.

Carboniferous.—At present there are no workings in the seams below the Top Hard; and those in the seams above this coal are confined to a few collieries.

On the west the Top Hard ranges from 5 ft. to a few inches over 6 ft. in thickness; but in the east, between Annesley and Bestwood, the seam gradually diminishes to under 3 ft., though at Oxton, which is the most easterly point at which it has been proved, the Top Hard shows a thickness of over 4 ft.

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[1] Explanatory Memoirs giving details of shafts and borings, are published.
[2] Maps and Explanatory Memoir are in course of preparation.

The Upper Coal Measures are present over a considerable area between Oxton, Gedling, and Thurgarton, but except at Thurgarton the sequence is confined to the lower beds or Etruria Marl group of this division of the Coal Measures, and from the evidence of the Kelham Boring it is not likely that the Upper Coal Measures will be found in any great thickness, if, indeed, they are present at all, north of a line joining Oxton and Kelham.

At Oxton the Middle Coal Measures above the Top Hard reach a thickness of 1,287 ft. Between here and the northern limit of the central area there are no shafts or borings that reach the Top Hard beneath the Upper Coal Measures, so that the full thickness of measures above the Top Hard is not known, but they may be expected to expand considerably north of Oxton (p. 22). This is a point of much importance in shaft sinking owing to the increase of cover in the same direction.

The section (No. 15, Appendix) obtained in the shafts of Mansfield Colliery may be regarded as typical of the character of the rocks and sequence of the seams. Here, and also at Oxton and Sherwood Colliery, the Mansfield Marine Bed (p. 20) with the hard bed of argillaceous limestone ('cank') resting on a thin coal at its base, forms a reliable index of position in the sequence which is otherwise not marked by the development of any very characteristic rock or seam of coal.

The measures, proved in actual mining, are inclined to the north-east at an angle varying from 2 to 5 degrees, but with a tendency, for the dip, to flatten gradually out to the east. From the evidence obtained at Thurgarton and Kelham it appears that the measures between these two localities rise to the east, and that for the present the Trent may be regarded as forming the eastern limit for the extension of this important coal in the southern part of the district. There are, however, no data giving the direction of the axis of the basin between Newark and Gainsborough. Should it trend nearly north and south then the Trent will again mark the eastern limit of the Top Hard, which in this case will lie at reasonable mining depths over the whole of the area, while the lower coals will also fall within the 4,000 ft. limit of working.

Bestwood Colliery.

(Plate III., Fig. 1.)

"The sinking of the shafts of this colliery was the first attempt made to reach the Top Hard Coal under the Trias at any considerable distance from known workings. The depth (1,241 ft.) at which the seam was attained proves, in the absence of any known faulting, that the dip of the measures flattens to the east, for if the dip of 5 degrees at the outcrop had continued, the depth to the Top Hard at Bestwood would have exceeded 2,000 ft.

"In the shafts the Top Hard is 6 ft. 8 in. thick, but gradually decreases in thickness when followed to the east. The inclination slowly diminishes in the same direction."[1]

[1] Excerpted from 'The Geology of Newark and Nottingham,' *Mem. Geol. Surv.*, 1908, p. 13.

Gedling Colliery.

(Section No. 11, Appendix, p. 92.)

"The success attending Bestwood Colliery and the proof obtained that the dip of the measures gradually decreased to S.E. and E. led to a boring being put down near Gedling. This experimental trial was considered to have reached the Top Hard at a depth of 1,372 ft. Two shafts were subsequently sunk near the site of the boring, and by the courtesy of the owners we were permitted to examine the material from time to time during the progress of the sinking . . .

"Respecting the first 20 ft. of 'red rock' we are unable to give any opinion, as the material had been covered up before our visit; but the underlying red and mottled marls (107 ft. thick) undoubtedly belong to the Etruria Marl Group . . . Shells of *Anthracomya phillipsi* were found to be fairly abundant throughout the first 109 ft. of strata beneath the Etruria Marls . . . Between 825 ft. (below which *A. phillipsi* was not found) and the Top Hard Coal several 'mussel bands' were met with [list given] . . . The absence of *Carbonicola robusta* is noteworthy. At 844 ft. a blue shale ('blue clunch' in the sinking record) yielded large forms of *Lingula* and *Orbiculoidea* in association with fish remains . . . At a depth of 1,022 ft. a similar shale contained *Lingula*. The bottom of this bed was a hard argillaceous limestone with *Lingula* and *Productus*." (From Survey Memoir, *op. cit.*, pp. 13-14.)

This occurrence of the fossils between the base of the Etruria Marls and the limestone (black hard stone of the record) at 1,022 ft. conforms with that above the Mansfield Marine Bed throughout the coalfield. It has been previously mentioned (p. 23) that the measures above the Mansfield Marine Bed rapidly diminish in thickness between Maltby and Oxton, while the attenuation below the marine bed and Top Hard amounts to only 6 ft. per mile. Between Oxton and Gedling, in a distance of six miles, the measures above the Mansfield Marine Bed fall from 757 ft. in thickness to 385 ft.; but those between the limestone at 1,022 ft. and the Top Hard also diminish from 528 ft. at Oxton to 352 ft. at Gedling, representing an attenuation of nearly 30 ft. per mile. On the stratigraphical evidence, therefore, some doubt exists as to the correct identification of the seam at 1,374 ft. depth with the Top Hard of other sinkings.

In the Memoir (p. 16) cited above it is stated that if "the *High Hazles* of Gedling be placed on a line with the *Clowne Coal* (623 ft.) of Bestwood it is found that the positions of the numerous coal seams in the two sections agree very closely, far more closely, indeed, than if the Top Hard Coal of Gedling is used as a base level." On this interpretation the discrepancy of the Mansfield Marine Bed lying below the Clowne Coal at Gedling and several feet above it over the rest of coalfield is avoided.

Thurgarton Boring.

(Section No. 22, Appendix, p. 118.)

The three subdivisions of the Upper Coal Measures are clearly distinguishable from each other by the lithological characters

mentioned on p. 26. The base of the Etruria Marls at 1,374 ft. is also clearly defined.

In the grey Coal Measures below the Etruria Marls the complete absence of coals from 1,614 ft. down to the bottom of the boring is most noteworthy; and this, in conjunction with the numerous beds of sandstone, can be best matched in the Lower Coal Measures. But this interpretation does not fit in with the marine bed at 1,672 ft. depth, which is either the bed 300 ft. above the Deep Hard Coal or the Mansfield Marine Bed. In the first case some signs of the coals between the Deep Soft and Silkstone coals should have been met with. If the bed is the Mansfield Marine Bed then on a comparison with Oxton the Top Hard Coal at Thurgarton should have occurred at 2,200 ft., but a slight increase in thickness of the measures at Thurgarton would place the Top Hard below the depth reached. Allowance must also be made for a deviation of the hole from verticality since the total depth given is measured by the length of the boring rods. The possibility of the lower part of the boring having passed through a fault which has introduced Lower Coal Measures should however be taken into account.

There is also some difficulty in taking the bed at 1,672 ft. to be the Mansfield Marine Bed since at Oxton the grey measures between the marine bed and the Etruria Marls are 754 ft. thick and only 298 ft. thick at Thurgarton. Either the measures thin rapidly or a part of the sequence has been cut out by faulting.

Oxton Boring.

(Plate III., Fig. No. 2, and Section No. 17, Appendix, p. 110.)

The breccia at the base of the Permian is of the usual Nottinghamshire type, and its presence leaves no doubt that the Coal Measures were entered at a depth of 516 ft.

The Coal Measures beneath the breccia consist of 110 feet of red and mottled clays of the characteristic Etruria Marl type, containing thin bands of greenish sandstones comparable with the Espley Rock of Thurgarton. As at Gedling, the group does not possess a clearly defined base, but, by the intercalation of grey with red measures, passes down into ordinary grey Middle Coal Measures.

The Middle Coal Measures belong to the Nottingham type, allowance being made for the difficulty of ascertaining by drilling the exact thickness of thin coals.

The fossils of the Mansfield Marine Bed include *Lingula mytiloides, Pterinopecten papyraceus, Posidoniella sulcata,* and goniatites.

Kelham Boring.

This important and interesting boring is situated on the left bank of the Trent, 1½ miles W.S.W. of the Midland Railway Station at Newark, at approximately 40 ft. above O.D. Operations have not yet ceased; but by the kindness of the directors of the syndicate we are permitted to publish the following notes on the points of chief geological interest.

The following classification of the newer formations passed through has been drawn up after an examination of the cores by Mr. B. Smith:—

		Thickness. Ft.	In.
	Soil and Trent alluvium	18	6
Trias ...	Keuper marl	397	6
	Waterstones	174	0
	Bunter Pebble Beds and Lower Mottled Sandstone.	671	0
Permian ...	Red marl	35	0
	Magnesian limestone	82	6
	Marl slates...	21	6
	Breccia	1	0

The Coal Measures were found at a depth of 1,401 feet below the surface and 1,361 feet below O.D.

The following notes on the igneous rock met with between 1,715 feet and 1,792 feet are supplied by Dr. Flett:—

The rock should be classed with the Teschenites, but it presents several characters which are unusual in rocks of this kind. It is ophitic to sub-ophitic in texture, and contains a purple augite and serpentinous pseudomorphs after olivine.

It is rich in analcite, which is often doubly refracting, and the felspars also exhibit analcitisation.

The strangest feature of the rock is the presence of a dark brown interstitial material which appears to be a primary constituent. This material is neither opal nor analcite, as its refractive index is higher than that of canada-balsam, and although probably a glass contains no globulites or trichites such as are usually present in the brown glass of dolerites. It is also quite unlike the material found in the glassy margins of teschenitic intrusions.

Beneath the igneous rock the boring was continued in shales and sandstones with coals to a depth of 2,361 ft. when it entered a hard coarse-grained sandstone containing a few rounded quartz pebbles and small garnets. After passing through a series of dark shales, with many marine shells, a pale-grey somewhat impure limestone containing a fragment of a compound coral was met with. There can, therefore, be little doubt that the strata below the depth of 2,361 ft. are older than the Coal Measures.

Mansfield Colliery.

(Plate III., Fig. No. 3, and Section No. 15, Appendix, p. 104.)

As at Oxton and in the shafts of the Sherwood Colliery, two miles west-north-west, the base of the Permian is clearly defined by the breccia at the depth of 468 ft. At Sherwood Colliery the breccia rests on a felspathic sandstone which has been stained red, but at Mansfield it lies on a pale-grey, unstained sandstone. Since both beds are equally porous the two sections illustrate the capricious action of the staining matter.

The section of No. 2 shaft given in the appendix shows the lithological characters of the Coal Measures sequence, and the fossils found in the Mansfield Marine Bed are indicated by the letter S in the list of fossils in Chapter II., p. 21. Although *Anthracomya phillipsi* occurs in the shales above the High Hazles Coal, 208 ft. above the Top Hard, it was only represented by a

few individuals, while the fossil was extremely abundant at the higher horizons between 900 and 1,000 ft. above the Top Hard.

In the workings, the Top Hard Coal is inclined three degrees to the north-east—276·7 ft. per mile.

South Scarle (Collingham) Boring.

(Plate II., Fig. 4.)

This boring is situated 17 miles nearly due east of the Mansfield Colliery. There are several published accounts of this record, which vary considerably in the details given of the thicknesses of the newer rocks, above the Coal Measures. The following figures are those given in the Coal Commission Report for 1905, pt. IX., Appendix , p. 43:—Superficial, 21; Lias, 29; Rhætic, 15; Keuper, 893·6; Bunter, 541·6; Permian, 519; all measurements being in feet. The basement bed of the Permian consisted of a breccia one foot thick,[1] at a depth of 2,020 ft. Beneath the breccia the boring was continued for 10 ft. in beds described by Wilson (*op. cit.*) as ' deep-red indurated marls with nodules of hæmatite,' and referred by him and others to the Upper Coal Measures, but as previously mentioned no importance can be attached to this identification of the beds with the red Upper Coal Measures of Thurgarton and Oxton.

Bevercotes Boring.

(Plate II., Fig. 5, and Section No. 4, Appendix, p. 77.)

This boring was continued below the Permian for some distance into the Coal Measures. The section of the Permian rocks is of interest as it is the farthest point north at which the basal breccia of the Permian has been proved.

Manton Colliery.

The shafts commenced in the Bunter Conglomerate and reached the Coal Measures at a depth of 620 ft. 10 in. from the surface. The Top Hard Coal was penetrated at a depth of 2,034 ft. Blocks of limestone and shale containing the characteristic fossils of the Mansfield Marine Bed were found on the refuse heaps, but the position of the band is not shown in the record.

3. Northern District.

With the exception of a boring at Haxey in the south-east, and of the collieries at Fryston and Peckfield in the north-west the development of this important area, amounting to about 600 square miles, has taken place within the present century. It is situated chiefly in south-east Yorkshire and is hence frequently called the ' East Yorkshire Coalfield.' In the south it is in direct continuation with the Nottinghamshire Coalfield from which it is not separated by any distinct geographical feature. The eastern

[1] E. Wilson, *Quart. Journ. Geol. Soc.*, vol. xxxv, 1879, p. 813.

boundary coincides with the Trent between Gainsborough and its confluence with the Humber. The northern boundary extends about two miles south of the Ouse at Selby; but thence to the west, the limit has not been fixed by borings and there is no information until the Peckfield Colliery is reached and the outcrop of the Millstone Grits to the north-west. The Magnesian Limestone between Maltby and north-west of Peckfield clearly defines the boundary on the west. Within these limits the whole of the area can be regarded as proved by shafts on the west and by borings in the north, east, and south.

The district falls within the one-inch Geological Survey maps, sheets 87, N.E., S.E.; 86, N.W., S.W., Old Series.

Cover.—The outcrop of the solid formations except those of the Permian are, for the most part, concealed by wide spreads of superficial deposits. The boundary lines, especially those between the sub-divisions of the Trias, are therefore not so easily determined as in the central district, consequently the thickness of the beds cannot be determined by observations at the surface. This, however, is of little practical consequence since, as in the central region, the distribution of the covering formations (Permian and Trias) was determined by the shape of the floor of Carboniferous rocks on which they were deposited and which, as the explorations show, (map, Plate I., and p. 3) was an even surface shelving east, so that both the Permian and Triassic sediments expand at a uniform rate in this direction. Every sinking to the east therefore meets not only with an increase of cover due to the easterly dip of the beds but also to their expansion. Since also the floor of Carboniferous rocks was inclined, not due east but a little north of east, the thickness of both Permian and Trias is not identical in borings on the same longitude but is always greater in the more northerly one.

The complete sequence of the Permian formation has been proved in several borings and sinkings, but the Triassic sandstones have been passed through in their entirety only at Haxey where they reach a thickness of 1,043 ft. (p. 96). At Haxey the Permian amounts to 557 ft. and at Selby to 624 ft., while the intermediate boring at Thorne gives a thickness of 622 ft.

As the outcrop of the Triassic sandstone is coincident roughly with the line representing the depth at which the buried coal-measure surface lies 500 ft. below sea-level and that of the Keuper Marl with the 1,700 ft. contour, the approximate amount of cover and its distribution can be obtained from the contour lines shown on the map (Plate I.).

The thickness of Drift (chiefly loose sands and gravels) can be determined only by actual trial since these deposits lie in irregular channels eroded in the solid formations. There are places where the Drift is thin or absent; and others, as at Bentley, where it amounts to 100 ft. One of the chief engineering difficulties in sinking shafts is the large volume of water contained in the Triassic sandstones, which are often of a soft spongy nature not unlike the unconsolidated Drift sands which gave so much trouble at Bentley Colliery. Water in considerable quantities occurs in the Lower Magnesian Limestone, if, as at Bullcroft, the rock is

fissured; but when more compact the amount of water does not present any serious obstacle in shaft-sinking.

Carboniferous Rocks.—In Yorkshire the seams of coal in the Lower and Middle Coal Measures, though continuous with those of Nottinghamshire and Derbyshire receive a totally different set of names (tables , pp. 12-14). The Top Hard Coal of Nottinghamshire becomes the Barnsley Coal of Yorkshire up to Wakefield. Further north, where dirt-partings make their appearance, it is called the Warren House Coal; and in its extreme northern extension it has been identified by Green with the Gawthorpe Coal (table, p. 15).

It is emphatically in search of the Barnsley Coal that all the explorations have been and are being made; and on its quality and thickness the success of any colliery primarily depends, just as in the region to the south the Top Hard Coal is held in the highest esteem.

In the Doncaster district the Barnsley Seam averages about 9 ft. in thickness, but of this only 6 to 7 ft. is marketable coal. It retains its character as an undivided seam to Thorne, a little south of the latitude of Wakefield; but whether partings set in north of Thorne has not been proved, though this may be settled by the borings at Pollington and Drax. Besides the Barnsley Coal, the Shafton Coal above and the Dunsil Seam below are of workable thickness, ranging from 4 to 6 ft.

The shafts of Maltby Colliery afford a complete and typical section of the measures above the Barnsley Coal, while the variation in their character is illustrated (Fig. 2, p. 24) by the section of Dinnington Colliery, four miles south-west of Maltby, and those of Cadeby and Bentley collieries (Sect. Nos. 5 and 3, Appendix) to the north-west and north. In the older sinkings of Cadeby and Dinnington no mention is made of the occurrence of marine beds, which, especially in the case of the Mansfield Marine Bed of Maltby and Bentley, afford definite and reliable zones; while the sandstones and coals, it will be observed, show rapid variations in thickness and character.

Except at Maltby the Upper Coal Measures were denuded before the deposition of the Permian rocks; but the erosion has not removed beds below the Shafton Coal, either in the north at Selby or in the east at Haxey and Thorne. If, however, as suggested (p. 47) the measures at Thorne are rising to the east, then the seams of the Middle Coal Measures will abut one after the other against the Permian rocks which will rest on Lower Coal Measures by the Trent, near Amcott (Fig. 3, p. 45), west of Crosby.

The structure of the coalfield is apparently that of a simple, shallow basin. Allowance, however, must be made for the limited amount of information to be obtained from underground workings and from borings, which are not sufficiently numerous or advantageously placed to supply the necessary data. But though the evidence is not complete, yet, so far as it goes, it indicates that the centre of the basin lies between Bentley Colliery and Thorne, and that its eastern margin does not extend for more than three or four miles east of the Trent.

Haxey Boring.

(Plates II. and III., Fig. 6, and Section No. 12, Appendix, p. 96.)

The first attempt to prove the Coal Measures in an area adjacent to the Trent, north of Gainsborough, was made at Idlestop, 3½ miles south-west of Haxey. This site was selected under a misconception, since corrected by Professor Kendall,[1] that the occurrence of coal fragments, which are frequently dredged off the Dogger Bank, indicated the outcrop of coal seams under the North Sea, and that the Coal Measures extended uninterruptedly from the visible coalfield to and beyond the Lincolnshire coast.

The record of the boring and a few notes have been published by Mr. G. Dunston. In his account it is mentioned that the seams were identified by Messrs. Hewitt and Chambers, and that the floor and roof of each coal were examined by Green and Russell, who are presumably responsible for naming the Carboniferous and Mesozoic rocks.

The boring was completed in 1893. It commenced with a diameter of 13 inches, which was gradually reduced to 1½ inches at the bottom. No mention is made of any determination of a possible deviation of the hole from verticality, so the statement that the measures are ' perfectly flat ' does not carry much weight. In the absence of any mention of fossils, it is impossible to compare, satisfactorily, the section with the recent sinking at Maltby and with those around Doncaster. All the seams between the Barnsley Coal and the Shafton Coal appear to have been passed through. We should, therefore, expect that one or more of the marine bands would have been detected, especially as Green was aware of their occurrence in the Yorkshire Coalfield.

On comparing the record with those of the recent sinkings, some modification of the published account appears to be justified. The mottled shales below 1,728 ft. probably represent the Marl Slates of Bentley Colliery and elsewhere, while the red colour of the sandstone (Rotherham Red Rock) on which they rest is due to staining frequently imparted to the rocks found above and below the Shafton Coal to the north and west. The coal (Barnsley Soft Coal) 4 ft. 9 in. thick at 3,142 ft., and the one (Barnsley Hard Coal) 4 ft. 7 in. thick at 3,185 ft., agree respectively with the Barnsley and Dunsil coals of Bentley Colliery (p. 65) and the Thorne Boring.

Maltby Colliery.

(Fig. 2, p. 24, and Section No. 14, Appendix, p. 98.)

The section is important as giving the complete sequence of the Middle Coal Measures above the Barnsley Coal in a district where they are at their maximum development. Particular care was taken by Mr. W. H. Dyson in the collection of fossils and in the correct description of the strata, of which adequate samples were taken and arranged in order in a cabinet. These and the material as it was brought up we were permitted to examine by the courtesy of Mr. Maurice Deacon, who also allowed us an inspection of the cores of a preliminary boring. It was expected that

[1] Final Report of the Royal Commission on Coal Supplies, pt. ix, 1905, p. 21.

the chief marine beds previously recorded from Brodsworth and Bentley by Mr. Culpin (*see* list, p. 21), would be found at Maltby. This anticipation was fully realised, owing to the enthusiastic search made by Mr. Dyson throughout sinking operations. The marine bands, it may be observed, were found in both shafts, and yielded the interesting and highly specialised fauna given in former pages (pp. 18-25).

On examining the cores of the preliminary boring near the site of the subsequent sinking, with the late Elmsley Coke and Mr. Maurice Deacon, it was concluded that some red and grey sandstones beneath the Magnesian Limestone were the same as those seen in the brick-pits at Conisborough, four miles to the north-west. If this view was correct, the boring entered Coal Measures about 100 ft. higher in the sequence than the shafts of Cadeby Colliery which, starting below the red marls of Conisborough give 2,211 ft. of measures above the Barnsley Coal. At Maltby the thickness amounts to 2,276 ft. It was calculated that the depth to the Barnsley would be from 2,450 to 2,500 ft. That the red marls of the boring occupy a high position in the Coal Measures and were most probably on the horizon of the Etruria Marls of Oxton, was indicated by the abundance of *Anthracomya phillipsi* shells found in the grey shales below. The red colour, therefore, is an original staining and is not derived from the overlying Permian strata.

Between the Barnsley Coal and the Mansfield Marine Bed the Maltby section agrees very closely with those of Bentley (Pl. III.) and Brodsworth; but above the marine bed it is difficult to fix the position of the Shafton Coal in the Maltby section. If the marine bed at 1,207 ft. is the same as the highest marine horizon at Bentley, the Shafton Coal will be represented either by one of the thin seams between 1,207 ft. and 976 ft., or by the coal at the last-mentioned depth. Here the seam, 1 ft. 4½ in. thick, rests on a sandstone, which may represent the Upper Chivet Rock of the Cadeby section (No. 5, Appendix, p. 78), which occurs 20 ft. below the Shafton Coal. The sandstone above will then be equivalent to the overlying stone bind of Cadeby and to the Thryberg Rock of Green. It is, however, difficult to reconcile this interpretation with Green's generalised section (table, p. 14), in which the next sandstone (Ackworth Rock) lies 500 ft. above the Shafton; while at Maltby a strong rock occurs only 152 ft. above the seam at 876 ft. We have, however, previously (p. 11) commented on the inadvisability of correlating one sandstone with another in the absence of other data—such as the marine beds. This is illustrated (Fig. 2, p. 24) by a comparison of the shaft section of Dinnington, in which only the Barnsley Coal can be recognised with any certainty with that of Maltby in which the sandstones and coals differ in number, position and thickness from those of Dinnington.

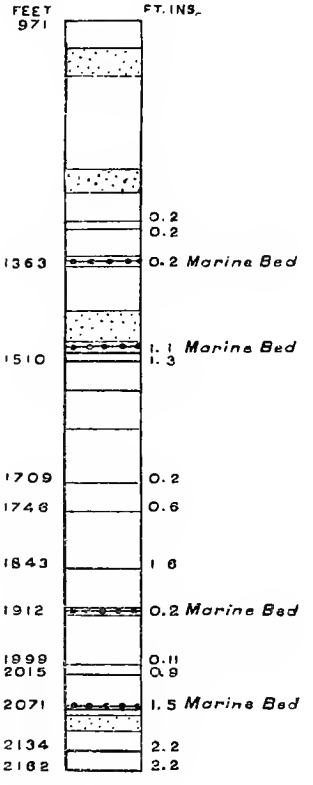
Armthorpe (Cantley) Boring.

(Plate II., Fig. 7, and Section No. 1, Appendix, p. 69.)

The Don faults (p. 39) if they continue in a north-easterly course under the newer formations would pass to the south of Bentley Colliery. The boring at Armthorpe was put down with

the object of testing the approximate depth to the Barnsley Coal previous to sinking, and it was not intended to reach the coal but to discontinue the boring when sufficient information had been obtained. The result of the boring shows that a fault of considerable downthrow south lies between Armthorpe and Bentley, but positive evidence of the amount of its throw and, consequently of the depth to the Barnsley Seam, was not obtained. Previously, the Mansfield Marine Bed had proved a satisfactory index at

FIG. 5.—*The Armthorpe Boring.*



Scale; *One Inch = 300 Ft.*

Numbers on left give depths from surface; those on right the thickness of coals. Chief sandstones shewn by stippling.

Brodsworth, at Thorne, and at Bentley. It was expected to yield the same satisfactory evidence here, but this hope was not realised in its fullest extent.

The cores were thrown open to our inspection through the courtesy of Mr. St. John Durnford, and were examined by us from time to time, when we also had the assistance of Mr. Culpin and of Elmsley Coke.

The boring entered Coal Measures at 971 ft. from the surface and was continued to a depth of 2,163 ft. without reaching the Barnsley Coal.

Tests for deviation, by the hydrofluoric acid method, were taken, and so far as can be judged the measures are nearly horizontal. There were some signs of faulty ground at 1,063 ft., which continued for 18 ft., when the measures again became normal and continued so down to the bottom of the boring.

The first 40 ft. of Coal Measures, consisting of mottled marls, bear a close resemblance to the Conisborough red marls.

In the grey measures below the faulty ground no absolutely definite beds of sandstone or coal were passed through; and as none of the four marine beds yielded a fauna distinctive of the Mansfield Marine Bed—each, with the exception of the one at 1,912 ft., in which fragments of goniatites were found, containing *Lingula* only—it is not possible to determine the position in the sequence at which the boring ended. The nearest correlation with Maltby is obtained by taking the bed at 1,363 ft. as equivalent to the one at 1,207 ft. or 1,245 ft. above the Barnsley Coal. This places the marine bed with goniatites at 1,912 ft. on about the level of the Mansfield Marine Bed, and that at 2,071 ft. with the bed at 1,888 ft., or 564 ft. above the Barnsley Coal, which would thus lie about 2,600 ft. from the surface or about 750 ft. deeper than at Bentley Colliery.

Bentley Colliery.

(Plate III., Fig. 7, and Section No. 3, Appendix, p. 74.)

These pits, in conjunction with those of Brodsworth and the boring at Thorne, prove an extension of the Barnsley Coal, with an average thickness of nine feet, over a considerable area. In addition, the Shafton Coal of Brodsworth and Bentley, and the Dunsil Coal in all three, attain a workable thickness. These coals would afford sufficient data in themselves for comparing the sections, but a closer comparison can be made by taking the Mansfield Marine Bed and tabulating in each section its distance in feet below the Shafton Coal and above the Barnsley Coal:—

	Brodsworth.	Bentley.	Thorne.
Shafton Coal	5 ft. 2 in.	4 ft. 0½ in.	1 ft. 9 in.
Measures	383	389	396
Mansfield Marine Bed...	20 ft. 4 in.	16 ft. 6 in.	15 ft.
Measures	705	676	566
Barnsley Coal	9 ft. 5 in.	9 ft. 8 in.	8 ft. 11 in.

During sinking operations a careful search for fossils was made by Mr. H. Culpin, who has published some notes, together with synoptical tables giving the range of the different fossils, plants, and animals.[1] Among the estuarine or fresh-water shells the absence of *Carbonicola robusta* as elsewhere (p. 11) is noteworthy, while the occurrence of *Anthracomya phillipsi* in profusion in the measures above the Shafton Coal is characteristic of the coalfield generally. A few individuals were found by Mr. Culpin in shales 100 ft. above the Barnsley Coal.

[1] For Bentley Colliery, *Proc. Yorks. Geol. Soc.*, vol. xvii., pt. i, 1909, pp. 75–81, and for Brodsworth Colliery, *Ibid.*, vol. xvi, pt. iii, 1908, pp. 321–334.

Thorne Boring.

(Plate III., Fig. 8, and Section No. 21, Appendix, p. 115.)

When permission to visit this boring was kindly granted by Mr. H. Embleton, the Triassic and Permian rocks had been passed through and the Coal Measures entered; but an examination of the cores of the Coal Measures was made on several occasions until the Barnsley Coal, 8 ft. 11 in. thick, was reached at a depth of 2,747 ft. beneath the surface, or 2,727 ft. below O.D.

The boring, situated on the western edge of Thorne Waste, lies nine miles north-east of Bentley village, near which the Barnsley Coal had been reached in a boring; but when operations commenced at Thorne there was no nearer exploration which would serve as a guide.

At the time of our first visit the coal, 1 ft. 9 in. thick, at the depth of 1,786 ft. had been penetrated, and it was thought by Mr. Embleton that it possibly represented the Shafton Coal. In the meantime the position of the Mansfield Marine Bed in relation to the Shafton Coal was ascertained by Mr. Culpin at Brodsworth. When this band with its distinctive fossils was entered at a depth of 2,167 ft. the approximate depth to the Barnsley Coal could therefore be calculated, and the near approach to the seam was indicated by the sandy shales with numerous plants at the depth of 2,739 ft. The boring was subsequently carried down to the coal, four feet thick, which agrees with the position of the Dunsil Seam of Bentley Colliery.

After allowance has been made for the deviation of the hole, which at one place was considerable, as tested by the hydrofluoric acid method, the measures are seen to be inclined at a gentle angle, though the exact amount is not measurable, but the Coal Measures are certainly not in a horizontal position. The inference drawn from the presence of inclined measures at Thorne has been stated in a previous chapter (p. 47).

Barlow Boring.

(Plate II., Fig. 10, and Section No. 2, Appendix, p. 72.)

This boring, situated nine miles north-north-west of Thorne, entered Coal Measures at a depth of 1,305 feet and was continued down to a depth of 2,371 feet. It has been described in detail by Mr. St. John Durnford,[1] from whose paper the following notes on the inclination of the measures and deviation of the hole from verticality are extracted:—

'At a depth of 2,122 feet, a seam of coal, 3 feet thick, was passed through . . . From this bed of coal to the bottom of the hole the cores were very much broken up. At 2,170 and 2,200 feet there was distinct evidence of faulting . . . Near the latter depth, the bedding-planes showed an apparent dip of about 70 degrees. From 2,200 feet to the bottom, the strata were, if anything, rather less disturbed . . . but the high

[1] *Trans. Fed. Inst. Min. Eng.*, vol. xxxiv, 1907–8, pp. 426–48.

inclination of the measures appeared to be accentuated with the greater depth, although a slight diminution was observable in the last 10 feet or so . . . The first test [for verticality] shows that the line of the hole at the depth of 2,120 feet was inclined to the vertical at an angle of about 15 degrees . . . in the second test, at 2,300 ft., the deviation was slightly less than was the case at the higher point, the angle being about 12 degrees.'

The boring obviously passed through faulted and possibly folded strata. Since the site lies two miles south of the line, considered in the Coal Commission of 1871, to mark the northern margin of the basin, the evidence, but for that subsequently obtained in the Selby Boring would be cited in support of this view.

Among faulted strata the examination of cores, especially in such characterless rocks as the Coal Measures, does not yield satisfactory evidence, and a personal inspection leaves the location of the sequence an open question. In the measures above 1,500 feet the occurrence of *Anthracomya phillipsi* indicates a position higher than the Barnsley Coal; and the presence of *Posidoniella sulcata* associated with *Pterinopecten papyraceus* and goniatites at 1,500 feet suggests the horizon of the Mansfield Marine Bed.

Selby Boring.

(Section No. 19, Appendix, p. 112.)

Situated one mile north-west of Barlow this boring has successfully proved that Coal Measures extend northward to and probably beyond the Ouse at Selby (p. 43).

For permission to examine, and, where necessary to break the cores, we are again indebted to Mr. St. John Durnford. We have also to acknowledge the assistance of Mr. H. Culpin on several occasions and for the information obtained by him from his own inspection of the cores.

After passing through 660 feet of loosely consolidated red sandstone, referable to the Bunter, the boring was continued through the Magnesian Limestone Series and entered Coal Measures at a depth of 1,284 ft.

The Permian strata showed little variation in thickness and character from the sequence at Barlow and making allowance for the absence of the rock salt in the middle marls they are 30 feet thicker than in the Barlow Boring. The Permian deposits therefore do not partake in that marked thinning which is so conspicuous in the Liassic and later Mesozoic sediments as they approach the Market Weighton anticline.

At the top of the Coal Measures, the reddish sandstones, although harder and showing some signs of bedding planes were scarcely distinguishable from the sands at the base of the Permian.

Towards the bottom of the hole the diameter of the core was under one inch so that the amount of dip could not be measured. Higher up, the measures, if not actually horizontal, were only slightly inclined; and since, as shown by frequent testing, the

hole was vertical, the amount bored—1,725 ft.—represents nearly the true thickness. Between 2,178 and 2,270 feet there were indications that the boring passed through a fault, but after a few feet of disturbed ground, the stratification again became normal. The boring therefore proved a considerable thickness of Coal Measures lying horizontally or only gently inclined at a point situated near the supposed northern margin of the basin.

The correlation of the strata with any known part of the Coal-Measure sequence does not, owing to the absence of sufficient data, admit of a satisfactory solution. Fossils indicative of a definite horizon were not found. The fragments of goniatites in the pale bluish shales at 1,775 ft., as well as a spirifer-like shell preserved in iron pyrites found by Mr. Culpin are not confined to any special marine bed though the shale band must be one above the Silkstone Coal as is shown by the great thickness and character of the measures below. Against its being the bed, 300 ft. above the Deep Hard Coal, is the absence of any signs of the Beeston coals, which are strongly developed in the northern part of the Yorkshire Coalfield. Presumably then it is one of the bands above the Barnsley Coal, which in the form of the Warren House Seam may have been passed through in the faulted ground at a depth of 2,261 ft., though on this interpretation it is again difficult to account for the failure of thick seams below this depth. The absence of any signs of the Gannister or Hard Bed Coal with its marine roof indicates that the boring did not reach the base of the Lower Coal Measures; and except for the failure of thick seams below the faulted strata, the general character of the measures suggests that the boring ended in Middle Coal Measures.

APPENDIX.

Records of Shaft-sinkings and Borings.

No. 1.

Armthorpe Boring.

1 in. Map (N.S.) 88 ; 6 in. Map, Yorks., 277 S.E.

Communicated by Mr. H. St. John Durnford.

Height above O.D. 50 ft.

[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In
		Soil	0	9	0	9
		Clayey sand and gravel	5	6		
		Brown sand and gravel, cobbles at bottom	14	4	20	7
Trias ...	Lower Mottled Sandstone and Bunter Pebble Beds.	Red sand	3	0		
		Soft red saudstone	13	6		
		Soft red sandstone with thin beds of conglomerate ...	8	0		
		Soft red sandstone	11	6		
		Soft red sandstone with small pebbles	43	6		
		Soft red sandstone	14	0		
		Soft red sandstone with pebbles	64	0		
		Soft red sandstone	143	5		
		Red marl	1	0		
		Red sandstone with some bands of marl	90	9		
		Red marl with grey sandstone bands	2	0		
		Red sandstone	57	0		
		Red sandstone and marl ...	8	0		
		Red sandstone	30	9		
		Grey marly sandstone	1	0		
		Red marl	2	6		
		Red sandstone	5	6		
		Red marl and marly sandstone	19	0	539	0
Permian ...	Upper Marls.	Red marl with pieces of gypsum	21	6		
		Red marl with gypsum bands and grey sandstone	11	0		
		Red marl with limestone and gypsum	5	3		
		Red marl, sandy marl, and gypsum	15	0		
		Marly gypsum	3	0		
		Blue and red marl	13	1	607	10
	Upper Limestone	Grey limestone	42	8	650	6
	Middle Marls.	Blue shale and sandy shale with gypsum and limestone ...	6	2		
		Red marl with gypsum ...	14	10		
		Red marl	2	0		
		Red marl with gypsum and grey sandstone	6	6		
		Red marl with bands of gypsum	77	3		
		Gypsum with thin veins of blue marl	8	0	765	3

Armthorpe Boring—*continued.*

			Thickness. Ft.	In.	Depth Ft.	In.
Permian—*cont.*	Basal Beds and Lower Limestone.	Grey limestone with gypsum	23	3		
		Grey limestone	5	6		
		Grey limestone with gypsum	28	6		
		Grey limestone	20	6		
		Grey limestone with gypsum	2	0		
		Grey limestone	12	5		
		Grey limestone with gypsum	8	0		
		Grey limestone	94	7		
		Grey shale	11	0	971	0
Coal Measures.		Mottled marl	11	6		
		Mottled sandy shale	10	3		
		Mottled shale with bands of red shaly sandstone	15	3		
		Mottled shale	2	0	1,010	0
		Grey sandy shale and sandstone ...	49	9		
		Grey fireclay	1	6		
		Grey fireclay, pieces of limestone ...	1	0		
		Grey limestone	1	3	1,063	6
		Grey shale and fireclay [faulty ground]	18	3		
		Grey shale	18	9		
		Black shale and coal	0	6	1,101	0
		Grey fireclay and ironstone	3	6		
		Grey shale	13	10		
		Black shale	0	8		
		Grey shale with ironstone	9	0		
		Grey shale with sandstone and black shale	7	0		
		Grey shale and sandy shale	27	0		
		Grey fireclay, black shale, and ironstone	2	6		
		Grey shale and sandy shale	18	8		
		Black shale	3	8		
		Grey shale with ironstone bands ...	4	6		
		Grey fireclay with ironstone ...	1	2		
		Grey sandstone	5	0		
		Grey shale	8	0		
		Grey shale, ironstone, and fireclay ...	1	6		
		Grey sandy shale, and shaly sandstone	38	9		
		Grey shale, some ironstone	21	9		
		Sandy shale and sandstone	11	3		
		Dark grey shale	3	0		
		Grey fireclay and ironstone	2	6		
		Grey shale and sandy shale, ironstone	7	6		
		Coal	0	2	1,291	11
		Dark grey fireclay	8	6		
		Ironstone	0	9		
		Dark grey fireclay	2	4		
		Coal	0	2	1,303	8
		Grey sandy shale, some ironstone ...	19	1		
		Grey shale	11	9		
		Grey shale with ironstone	10	0		
		Bluish grey shale with ironstone ... (Marine shells.)	17	6		
		Dark grey shale (Marine shells.)	1	0		
		Coal	0	2	1,363	2
		Grey fireclay	0	3		
		Grey shale and sandstone	6	8		
		Grey fireclay with ironstone ...	2	8		
		Grey sandstone and sandy shale ...	18	9		
		Grey sandy shale and shale, with ironstone	26	3		

Armthorpe Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Grey sandstone and sandy shale ...	65	0		
	Dark grey shale and ironstone [*Lingula*]	13	3		
	Coal	1	1	1,497	1
	Dark grey fireclay	10	8		
	Grey shale with ironstone	1	9		
	Coal, bastard	1	3	1,510	9
	Grey fireclay with ironstone	9	3		
	Grey shale	6	9		
	Grey fireclay, with ironstone ...	10	0		
	Grey shale with ironstone	9	3		
	Grey fireclay with ironstone... ...	5	8		
	Shaly sandstone and sandy shale ...	91	8	1,643	4
	Dark grey shale with ironstone bands	6	8		
	Bluish grey shale	2	0		
	Black shale	0	6		
	Sandy fireclay with ironstone ...	2	0		
	Grey sandy shale and ironstone ...	3	6		
	Bluish grey shale	3	6		
	Dark grey shale with ironstone, coal joints	0	6		
	Grey fireclay	1	2		
	Grey shale and sandy shale	43	7		
	Dark grey shale with ironstone ...	1	2		
	Coal, bastard	0	4		
	Dark grey fireclay	1	5		
	Coal	0	2	1,709	10
	Grey fireclay	2	11		
	Grey shale with ironstone	27	9		
	Black shale	1	0		
	Dark grey fireclay	4	0		
	Coal, bastard	0	6	1,746	0
	Grey sandy shale	5	0		
	Grey shale and sandy shale, some ironstone	84	0		
	Dark grey shale	7	0		
	Coal	1	6	1,843	6
	Fireclay and sandy fireclay with ironstone	3	5		
	Grey sandy shale and sandstone ...	30	3		
	Grey shale and ironstone	9	0		
	Dark grey shale and ironstone ...	8	4		
	Very dark grey shale with ironstone bands [*Lingula*]	10	8		
	Grey limestone, cank [*Lingula*] ...	0	5		
	Very dark grey shale [*Lingula*] ...	6	5		
	Anthracite coal	0	2	1,912	2
	Grey fireclay	5	6		
	Grey sandstone	1	6		
	Sandy fireclay	7	7		
	Mottled shale	3	5		
	Fireclay with ironstone	8	4		
	Grey shale	15	0		
	Grey fireclay, ironstone, gas coal joints	6	0		
	Grey shale, ironstone	9	10		
	Black shale, ironstone	5	2		
	Dark grey shale, ironstone	3	3		
	Sandstone and sandy shale	5	0		
	Fireclay with ironstone	3	6		
	Sandy shale and sandstone	4	6		

Armthorpe Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Grey shale and bands of ironstone ...	7	10		
	Coal	0	11	1,999	6
	Fireclay	15	0		
	Coal, soft	0	9	2,015	3
	Fireclay with ironstone	4	0		
	Grey shaly sandstone and sandy shale	14	3		
	Grey shale, ironstone...	20	6		
	Grey sandy fireclay	5	6		
	Very dark blue shale and ironstone bands...	10	0		
	Grey shale, ironstone bands [*Lingula*]	1	0		
	Coal	1	5	2,071	11
	Grey fireclay with ironstone... ...	4	4		
	Grey sandy shale	1	0		
	Grey shale and sandstone, ironstone	13	0		
	Grey shaly sandstone...	5	0		
	Grey sandy shale with ironstone bands	4	9		
	Grey shale with ironstone bands ...	26	6		
	Black shale	6	1		
	Coal	2	2	2,134	9
	Fireclay	3	0		
	Grey shale and shaly sandstone ...	23	0		
	Coal	2	2	2,162	11

No. 2.

Barlow Boring.

1 in. Map (N.S.) 79 ; 6 in. Map, Yorks., 236 N.E.

Communicated by Mr. H. St. John Durnford.

Height above O.D. 16·1 ft.

[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
		Dark brown clay	38	0		
		Red sand	1	0		
		Clay	15	0		
		Sand	40	0	94	0
Trias ...	Bunter Sandstone.	Red sandstone	186	0		
		Mottled red marl	2	0		
		Red sandstone	300	0		
		Red sandstone, mixed with marl	43	0		
		Grey sandstone	45	0		
		Red sandstone	2	0		
		Red marl...	1	0		
		Red sandstone	22	0	695	0
Permian ...	Upper Marls.	Red marl...	6	0		
		Red marl with sandstone layers	4	0		
		Red marl...	14	0		
		Red marl and sandstone ...	1	0		
		Red marl...	34	0		
		Gypsum and anhydrite... ...	20	0		
		Red marl and gypsum	5	6		
		Red marl...	16	6		
		Marl with bands of gypsum ...	4	0	800	0
	Upper Lime-stone.	Limestone with bands of gypsum	16	0		
		Limestone	77	6		
		Limestone with bands of shale and gypsum ...	10	0	903	6

Barlow Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Permian—*cont.*	Lower and Middle.	Red marl with layers of limestone	64	0		
		Rock salt...	20	0		
		Limestone	20	6		
		Blue marl	1	0		
		Anhydrite	5	6		
		Blue marl	1	0		
		Limestone	4	6		
		Red marl...	1	0	1,021	0
		Limestone	25	6		
		Limestone with veins of gypsum	45	0		
		Limestone	213	6	1,305	0
Coal Measures.		Grey shale	12	0		
		Blue shale	31	0		
		Grey shale	28	0		
		Dark shale	18	0		
		Blue shale	12	0		
		Sandstone and sandy shale with coal layers	15	0		
		Blue shale with sandstone layers ...	19	0		
		Blue shale [Marine bed at base] ...	60	0		
		Fireclay	1	0	1,501	0
		Blue shale	18	0		
		Light coloured sandy shale	7	0		
		Blue shale	45	0		
		Grey shale	6	0		
		Dark coloured shale, ironstone nodules	7	6		
		Sandy shale	4	6		
		Dark blue shale	26	0		
		Coal	1	3	1,616	3
		Fireclay	4	0		
		Blue shale	29	9		
		Grey shale and sandstone layers ...	32	0		
		Blue shale	9	0		
		Stone bind	13	0		
		Dark blue shale	27	0		
		Fireclay	1	0		
		Sandstone and stone bind	12	0		
		Blue shale	24	0		
		Dark coloured shale	4	0		
		Fireclay	4	0		
		Stone bind	5	0		
		Light and dark coloured shale ...	19	0		
		Light grey sandstone	14	0		
		Blue shale	5	0		
		Stone bind	18	0		
		Blue bind	3	0		
		Stone bind	2	0		
		Blue shale	41	0		
		Grey sandstone	41	0		
		Coal	0	9	1,924	9
		Fireclay	4	0		
		Shale	55	3		
		Stone bind	74	0		
		Blue shale	61	0		
		Coal, inferior	3	0	2,122	0
		Fireclay	8	0		
		Light coloured stone	40	0		
		Blue shale	8	0		
		Light coloured stone	17	0		
		Blue shale with coal veins	22	0		
		Grey sandstone	63	0		
		Blue shale	91	0	2,371	0

No. 3.

Bentley Colliery.

Section in No. 2 Shaft at the Bentley Colliery.
1 in. Map (N.S.) 88 ; 6 in. Map, Yorks., 277 N.W.
Communicated by Mr. R. Clive.
Height above O.D. 21 ft.
[Slightly abridged.]

		Thickness. Ft.	In.	Depth. Ft.	In.
	Soil	0	9	0	9
	Yellow and blue clay	13	11		
	Warp clay	1	4	16	0
Glacial.	Sand, sandy clay with fragments of coal	63	0		
	Sandy red and blue clay with coal and boulders	13	4		
	Stiff blue clay with glacial boulders	7	8	100	0
Permian. — Upper Permian Marl and Bunter Sandstone.	Soft red and grey sandstone	28	6		
	Red marl and sandstone	29	2		
	Red marl with boulders	22	10		
	Broken limestone	1	4		
	Red marl	3	0	184	10
Upper Limestone.	Grey limestone	24	10		
	Grey limestone with clay partings	3	9		
	Dark grey limestone with gypsum partings	24	7	238	0
Middle Marl.	Dark grey marl with gypsum	1	0		
	Red marl with gypsum	28	0		
	Harder gypsum with limestone	2	10		
	Limestone with clay partings	2	2	272	0
Basal Beds and Lower Limestone.	Grey limestone	204	0		
	Dark grey limestone with clay partings	9	0		
	Dark grey limestone with pyrites and [galena]	11	10		
	Very soft dark brown clay	0	2		
	Dark limestone with bands of hard marl	8	6		
	Strong grey marl [*Lingula credneri*]	15	10	521	4
Coal Measures.	Soft mottled blue and red shale	9	0		
	Blue bind and sandstone (3 ft. 3 in.)	19	5		
	Stone bind and sandstone	70	6		
	Coal	0	5		
	Fireclay	0	5		
	Bind, clunch, and fireclay, alternating	80	2		
	Grey sandstone	9	9		
	Blue bind / Black shale — Marine Bed	20	8		
		0	4	732	0
	Blue bind	3	6		
	Black shale, streaked with coal	0	11		
	Fireclay and clunch	4	5		
	Blue bind	36	1½		
	Black shale	1	1½		
	Coal [? Shafton]	4	0½	782	1½
	Fireclay	4	3½		
	Black shale and clunch	1	7		
	Coal	0	10	788	10
	Fireclay	2	3		
	Bind and sandstone (3 ft.) mixed	59	9		
	Coal	1	4	852	2
	Clunch	3	4		
	Blue bind	33	7		

Bentley Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Coal	0	1½	889	2½
	Blue bind	4	6½		
	Grey sandstone	17	10		
	Blue bind with ironstone bands ...	6	0		
	Black shale	0	7		
	Coal	1	1	919	3
	Fireclay and clunch	4	6		
	Blue bind	11	10		
	Sandy blue bind with bands of grey sandstone	30	5		
	Grey sandstone	51	0		
	Strong stone bind with bands of sandstone	6	0		
	Mottled grey sandstone and stone bind	34	6		
	Very dark grey bind with ironstone bands...	6	0		
	Fireclay and clunch	2	6		
	Grey bind and ironstone bands ...	11	0		
	Hard clunch	4	0		
	Strong blue bind with bands of sandstone	10	0		
	Blue bind	6	4		
	Black shale	3	3		
	Coal	1	6	1,102	1
	Fireclay	6	0		
	Blue bind	5	0		
	Bind with sandstone bands	57	5		
	Black shale	1	9		
	Blue bind with ironstone balls ...	4	6		
	Dark shale with hard cank balls above coal [Mansfield Marine Bed] ...	10	9	1,187	6
	Coal with black batt	0	5	1,187	11
	Fireclay and clunch	2	10		
	Clunch and stone bind	11	3		
	Coal, bright	0	8	1,202	8
	Clunch	2	2		
	Blue bind	2	7		
	Stone bind and sandstone	25	6		
	Dark blue bind	6	1		
	Coal 7 in., clod 3 in., Coal 1 ft. 1 in.	1	11	1,240	11
	Dark clunch	3	4		
	Bind with hard bands	19	2		
	Coal	0	4	1,263	9
	Clunch and fireclay	2	8		
	Black clunch with ironstone balls ...	7	1		
	Ironstone bands	0	5	1,273	11
	Blue bind (Marine bed at 1,274 ft.)...	18	2		
	Stone bind with beds of cank ...	11	8		
	Blue bind	7	7		
	Coal (bright) 9 in., hard Coal 1 ft. 3 in.	2	0	1,313	4
	Hard clunch	6	6		
	Clunch and stone bind	4	1		
	Black bind with fossils	8	0		
	Ironstone band	0	4		
	Black bind with fossils	2	8		
	Blue bind with bands of ironstone and fireclay	20	11		
	Black bind with coal streaks... ...	1	2		
	Black batt and coal	0	3		
	Light clunch and fireclay	3	7		
	Dark clunch and bind...	3	8		
	Blue bind with ironstone bands ...	6	7		

Bentley Colliery—*continued.*

		Thickness. Ft.	In	Depth. Ft	In.
Coal Measures —*cont.*	Coal, tender, brassey [Melton-field]	3	4	1,374	5
	Clunch	6	9		
	Grey rock and shaly sandstone ...	3	9		
	Blue bind with ironstone bands ...	4	1		
	Black bind	1	7		
	Fireclay and clunch	3	11		
	Strong stone bind	1	4		
	Blue bind with ironstone	24	9		
	Black bind	6	10		
	Coal, cannel, 10 in., Coal 4 in., batt 2½ in., Coal 4½ in.	1	9	1,429	2
	Clunch and bind with ironstone ...	1	11		
	Coal	1	4	1,432	5
	Dark clunch	0	4		
	Stone bind and cank	13	11		
	Strong blue bind	2	7		
	Blue bind with ironstone bands ...	15	5		
	Black bind with *Lingula* above coal...	6	1		
	Cannel Coal...	3	8	1,474	5
	Bind and clunch, mixed	21	9		
	Coal	2	3	1,498	5
	Black batt	0	10		
	Dark clunch	0	11		
	Stone clunch	3	1		
	Strong stone bind with sandstone bands...	12	1		
	Black shale	1	2		
	Blue bind	9	4		
	Dark bind	0	6		
	Coal	0	9	1,527	1
	Batt and clunch	4	8		
	Clunch	1	8		
	Stone bind and sandstone bands ...	113	6		
	Blue bind with ironstone bands ...	9	6		
	Dark brown shale	1	0		
	Stone bind and sandstone bands ...	21	2		
	Blue bind with ironstone bands ...	9	2		
	Black shale, fossil shells	0	2		
	Dark blue bind	2	5		
	Coal, hard, with pyrites [Kent's Thick]	2	3	1,692	7
	Clunch	1	11		
	Stone bind	11	11		
	Blue bind	7	6		
	Coal	1	1	1,715	0
	Dark clunch	0	2		
	Dark bind	1	2		
	Sandstone and stone bind	17	9		
	Dark bind	1	7		
	Clunch with coal parting	3	0		
	Stone bind	20	5		
	Black bind	3	11		
	Stone bind and sandstone	19	10		
	Blue bind	22	5		
	Coal	0	5	1,805	8
	Batt	0	3		
	Dark clunch with ironstone balls ...	3	11		
	Stone bind with ironstone	3	4		
	Strong stone bind and sandstone ...	9	9		
	Blue bind with ironstone balls ...	3	10		
	Black shale	0	5		

Bentley Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Blue bind with ironstone bands and balls	7	9		
	Blue bind with ironstone bands ...	6	0		
	Stone bind	2	9		
	Bind with ironstone bands	14	2		
	Batt	0	2		
	Coal	1	6	1,859	6
	Clunch	2	0		
	Bind and batt	1	6½		
	Coal, Barnsley (*See* p. 16) ...	9	8	1,872	8½
	Batt	0	5		
	Sandy clunch	0	5		
	Bind and sandstone, alternating ...	46	11½		
	Coal, Dunsil (*See* p. 13)	5	1	1,925	7
	Coal pyrites	0	7		
	Soft clunch	0	8		
	Coal	0	1½		
	Clunch with ironstone balls	3	11½		
	Stone bind	4	10		
	Sandstone	1	0		
	Stone bind with bands of ironstone...	1	6		
	Clunch with ironstone balls	3	7		
	Sandstone and stone bind with ironstones	9	1		
	Black shale with bands of cannel coal	0	10		
	Sandstone and stone bind	10	3	1,962	0

No. 4.

Bevercotes Boring.

1-inch Map (N.S.) 113 ; 6-inch Map, Notts., 19 N.E.

Communicated by Mr. A. E. Webster.

Height above O.D. about 95 ft.

[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
	Clay		2	0		
	Peat		2	2		
	Grey sand and sandy gravel		5	7	9	9
Trias ...	Keuper Waterstones.	Red loamy sand ...	1	6		
		Rotten red sandy marl ...	7	8		
		Blue loamy sand with mica	1	6		
		Red and blue sandy marl	15	1		
		Red, shaly sandstone, with mica	2	0	37	6
	Lower Mottled Sandstone and Bunter Pebble Beds.	Red and grey sandstone ...	11	0		
		Red and blue marl, jointy ...	7	6		
		Red and grey sandstone and sandy shale	28	10		
		Red and blue sandy marl ...	2	0		
		Coarse red and blue sandstone, soft	116	2		
		Red marl	0	4		
		Red sandstone with gravel stones	134	6		
		Red marl	0	6		
		Coarse red sandstone with gravel stones	266	11	605	3
		Red sandstone	54	11		
		Red and grey sandstone, with bands and balls of marl ...	59	2	719	4

Bevercotes Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Permian ...	Upper Marl.	Red and blue marl	3	2	722	6
	Upper Limestone.	Light grey limestone, with joints of marl	4	6		
		Red and blue sandy marl	2	10		
		Limestone, containing shale	18	2	748	0
	Middle Marl.	Red and grey sandy marl, shale and sandstone ...	53	8		
		Red marl with spar cavities...	5	6		
		Grey sandstone	0	3		
		Red marl	34	7		
		Red and grey sandstone, sandy marl and shale	59	4	901	4
	Basal beds and Lower Limestone.	Dark-grey limestone, with shaly partings, bands, &c.	120	0		
		Grey limestone, with shale joints and bands ...	82	3		
		Blue shale	26	6		
		Conglomerate	6	0	1,136	1
Coal Measures.						

No. 5.

Cadeby Colliery.

Section in the Downcast Shaft at the Cadeby Colliery.

1 in. Map N.S. 87. 6 in. Map Yorks, 284 N.W.

Height above O.D. 200 approx.

[Abridged from MS. in Survey Office.]

		Thickness. Ft.	In.	Depth. Ft.	In.
	Soil	1	0	1	0
	Gravel	10	0		
	Light blue clay	7	0		
	Sandstone	2	0		
	Yellow and blue clay	7	0		
	Gravel	5	0	32	0
Coal Measures	Sandstone	1	6		
	Yellow and blue bind...	16	6		
	Sandstone	5	0		
	Blue clay	2	4		
	Coal	2	6	59	10
	Spavin	16	6		
	Coal	1	0	77	4
	Spavin	13	5		
	Grey bind	5	3		
	Greet stone	4	0		
	Soft spavin	4	1		
	Coal	1	6	105	7
	Soft spavin	8	3		
	Blue bind	23	2		
	Blue bind with ironstone balls ...	38	0		
	Sandstone rock	26	0		
	Soft bind	0	9		
	Sandstone rock	8	9		
	Soft black shale	1	6		
	Spavin and blue bind...	10	6		
	Coal	2	0	224	6
	Clunch and spavin	2	6		

Cadeby Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Grey rock, stone bind, bind and spavin alternating	33	5		
	Black shale	0	6		
	Coal	0	6	261	5
	Spavin	4	6		
	Rock and bind alternating	32	3		
	Black shale	0	4		
	Spavin	9	5		
	Bind and spavin with ironstone balls	4	0		
	Rock and bind	2	0		
	Rock	68	0	381	11
	Clunch and bind	14	6		
	Coal	0	11		
	Clunch	1	9		
	Coal, 3 in.; spavin, 1 ft. 0 in.; Coal, 9 in.	2	0	401	1
	Spavin	3	6		
	Bind and rock mixed	57	6		
	Coal	2	0	464	1
	Spavin stone	4	6		
	Bind	42	4		
	Coal	1	11	512	10
	Soft dark spavin	2	9		
	Grey rock and blue bind	15	9		
	Coal	0	3	531	7
	Spavin and coal smuts	1	4		
	Fireclay	4	0		
	Bind and stone bind	17	3		
	Coal	0	6	554	8
	Stone spavin	12	0		
	Stone bind	6	7		
	Spavin and stone spavin	2	5		
	Stone bind and rock	2	10		
	Blue bind	13	1		
	Grey rock	4	2		
	Bind and dark shale	14	10		
	Coal	0	6	611	1
	White spavin	13	7		
	Bind, stone bind, and rock	20	4		
	Sandstone rock	72	0		
	Bind	1	3		
	Coal	0	2	718	5
	Spavin	7	9		
	Stone bind and rock	14	4		
	Bind and stone bind	16	8		
	Coal, 1 in.; spavin, 1 ft.; Coal, ½ in.	1	1½	758	3½
	Spavin	3	9½		
	Bind and stone bind, mixed	52	9		
	Coal	0	11	815	9
	Spavin stone	5	6		
	Grey rock and bind, mixed	13	9		
	Blue bind	33	5		
	Black shale	4	0		
	Coal	0	2	872	7
	Spavin	9	3		
	Black shale	1	6		
	Stone bind	16	1		
	Coal, Shafton	3	0	902	5
	Spavin and stone spavin	10	5		
	Blue bind	19	10		
	Rock with thin partings (Upper Chivet Rock)	100	2		

Cadeby Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Dark blue bind with ironstone lists...	6	9		
	Coal	1	3	1040	10
	Spavin and stone spavin	3	4		
	Stone bind and white rock	6	11		
	Blue bind	12	11		
	Stone spavin and stone bind, mixed...	39	10		
	Dark bind	4	3		
	Coal	0	1	1108	2
	Dark soft spavin	0	4		
	Stone bind	1	6		
	Blue bind	22	0		
	Coal ... ... (Cudworth.)	1	8		
	Dark earth and shale ... (Cudworth.)	2	3		
	Coal, 2 in.; parting, 6 in.; Coal, 2 ft. (Cudworth.)	2	8	1138	7
	Spavin	5	0		
	Stone bind	10	4	1153	11
	Dark bind	2	6		
	White cank	0	6		
	Blue bind	13	6		
	Bind and black shale	2	0		
	Bastard cannel and shale	0	11	1173	4
	Stone bind	16	1		
	Blue bind and black shale, mixed ...	3	9		
	Coal	0	3	1193	5
	Dark spavin	1	4		
	Stone bind and rock	7	6		
	Blue bind	4	7		
	Coal, soft, 1 ft. 7 in.; shale ¼ in.; Coal, hard, 4 in.	1	11	1208	9
	Clunch	3	7		
	Blue bind	11	5		
	Stone bind and bind	27	5		
	Coal	0	1	1251	3
	Dark earth	4	0		
	Clunch	4	0		
	Bind and rock, alternating	110	5	1369	8
	Blue bind	18	4		
	Dark shale	2	0		
	Dark blue bind	13	9		
	Black shale	1	8		
	Coal	0	2	1405	7
	Fireclay	3	0		
	Stone clunch	6	0		
	Stone bind	10	3		
	Blue bind	21	0		
	Rock and stone bind	5	6		
	Black shale	2	0		
	Coal, 1 ft. 3 in.; shale, 3 in.; Coal, 11 in.	2	5	1455	9
	Dark shale	1	0		
	Coal	0	2		
	Stone clunch, cank 4 in.	7	4		
	Stone bind and blue bind, mixed ...	74	2		
	Blue bind	12	5		
	Grey rock	1	0		
	Blue bind and stone lists	8	0		
	Blue bind	6	0		
	Ironstone	0	2		
	Blue bind	7	8		
	Coal, Newhill	2	1	1575	9

Cadeby Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Blue stone spavin	6	0		
	Grey stone clunch	4	4		
	Blue bind, rock 4 ft. 10 in. at 1601 ft. 3 in.	43	0		
	Coal	0	2	1629	3
	White earth	4	0		
	Blue bind	3	0		
	Stone bind	14	0		
	Blue and dark bind	10	4		
	Coal, Meltonfield	3	0	1663	7
	Stone spavin	3	10		
	Grey rock and stone bind	12	10		
	Blue and dark bind	12	7		
	Stone spavin	7	0		
	Blue bind	29	8		
	Black bind and shale	3	9		
	Coal, 1 ft.; coal and dirt, 2 ft.; Coal, 10 in.	3	10	1737	1
	Stone spavin	4	0		
	Stone bind	18	10		
	Coal	0	5	1760	4
	Dark clunch and shale	2	10		
	Stone bind	35	6		
	Blue bind	6	2		
	Grey rock with thin partings of stone bind	89	6		
	Coal	2	10	1897	2
	Clunch	6	0		
	Blue bind with ironstone balls ...	13	0		
	Blue bind	6	0		
	Coal	0	6	1922	8
	Grey spavin	5	0		
	Blue bind	12	6		
	Coal, Kent's Thin	1	9	1941	11
	Dark spavin	2	6		
	Grey rock and stone bind	14	0		
	Blue bind with ironstone balls ...	15	0		
	Coal	1	3	1974	8
	Shaley spavin	0	6		
	Grey rock with cank and stone bind	9	0		
	Blue bind	9	7		
	Grey bedded rock	12	0		
	Bind	15	8		
	Stone bind with cank balls	14	3		
	Coal, Kent's Thick...	1	10	2037	6
	Stone spavin	4	0		
	Stone bind and grey rock	35	11		
	Bind	11	0		
	Cannel Coal	1	0	2089	5
	Black bind and spavin	2	0		
	Rock	12	0		
	Blue bind with ironstone balls ...	12	0		
	Coal	1	0	2116	5
	Clunch and bind	6	0		
	Stone bind and rock	26	9		
	Bind	21	0		
	Strong stone lists	19	6		
	Dark bind	3	0		
	Coal 1 ft. 5 in., batt 2 in., Coal (Cannel) 7 in.	2	2	2194	10
	Dark blue bind	4	0		

Cadeby Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Coal	0	1		
	Blue bind	5	9		
	Stone bind and rock	28	7		
	Blue bind and black shale	7	0		
	Strong blue bind	1	0		
	Clod with ironstone bands	2	0		
	Coal, Barnsley Coal	10	3	2253	6
	Clod	2	0		
	Stone clunch	6	0	2261	6

No. 6.

Carlton (West Bank) Boring.

1-in. Map (N.S.) 79 ; 6-in. Map, Yorks., 236 S.E.

Communicated by Prof. P. F. Kendall.

Height above O.D. 20 ft.

[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
	Surface soil and a little blue clay ...		10	0		
	Brown clay		35	0		
	Running sand		15	0	60	0
Trias ...	Bunter Sandstone.	Soft sandstone	166	0		
		Running sand	3	0		
		Soft red sandstone	81	0		
		Running sand	10	0		
		Red sandstone	205	0		
		White sandstone	1	6	526	6
Permian ...	Upper Marls.	Red marl	13	6		
		Red sandstone	7	0		
		Red and white sandstone intermixed	7	0		
		Variegated marls	15	0		
		Red marl	15	0		
		Ornamental gypsum	20	0		
		Red marl and gypsum intermixed	25	0	629	0
	Upper Limestone.	Limestone	94	0		
		Gypsum and limestone intermixed	10	0	733	0
	Middle Marls.	Red marl and gypsum ...	33	0		
		Red marl and limestone ...	10	0		
		Red marl and thin beds of shale and gypsum	36	0		
		Shale and gypsum	6	0		
		Red marl and gypsum ...	33	0	851	0
	Lower Limestone.	Limestone	215	0		
		Blue sandstone, very soft (? Basal sands)	25	0	1091	0
Coal Measures.	Sandstone, rather shaly		7	0		
	Blue shale		7	0		
	Red and white sandstone		24	0		
	Shale and sandstone, intermixed ...		27	0		
	Blue shale		32	0		
	Coal		1	6	1189	6
	Dark spavin		0	10		
	Blue shale		31	8		
	Coal		0	10	1222	10

Carlton (West Bank) Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Blue shale	29	7		
	Blue shale and thin beds of sandstone	9	0		
	Black shale	2	0		
	Coal	1	0	1264	5
	Blue shale	2	0		
	Light shale	3	6		
	Very dark shale	3	6		
	Blue shale	2	6	1275	11
	Coal	0	10		
	Black shale and spavin	4	8		
	Blue shale	9	6		
	Coal	0	2	1291	1
	Blue shale	6	4		
	Sandstone and thin bands of shale ...	7	0		
	Coal	0	6	1304	11
	Shale	53	0		
	Coal	2	8	1360	7
	Dark shale	11	4		
	Coal	0	3	1372	2
	Blue shale	10	9		
	Coal and shale, intermixed ...	1	0	1383	11
	Light blue shale	47	6		
	Soft sandstone and blue shale ...	63	0		
	Dark shale	6	6		
	Fireclay	0	6		
	Light stone	1	0		
	Dark shale and thin beds of coal 1 ft. 8 in. thick	17	0		
	Light stone and shale	21	0		
	Blue and brown shale	15	0		
	Dark shale	5	0		
	Coal	0	3	1560	8
	Dark shale	4	9		
	Blue shale	36	0	1601	5

No. 7.

Clifton Colliery.

1-inch Map (N.S.) 126 ; 6-in. Map, Notts., 42 S.W.

Abridged from MS. in Survey Office.

Height above O.D. 80 ft.

		Thickness. Ft.	In.	Depth. Ft.	In.
	Alluvium (soil and gravel)	24	10	24	10
Trias ...	Red and grey sandstone	131	8		
	Conglomerate	0	11	157	5
Coal Measures.	Pink and purple bind	3	3		
	Blue bind	1	8		
	Brown and purple sandstone ...	7	6		
	Grey rock	3	11		
	Bind	5	1		
	Coal, Coombe	2	8	181	6
	Clunch	5	3		
	Blue bind with ironstone	13	7½		
	Coal	0	6		
	Clunch	0	11		
	Coal	0	8		
	Clunch	2	1½		
	Coal, Top Hard	5	11½	210	6½
	Clunch and bind	36	10½		

Clifton Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Stone bind and rock	17	8		
	Bind	12	11		
	Coal, Dunsil	3	0	281	0
	Clunch and bind	24	1		
	Coal, Waterloo	3	3	308	4
	Clunch and bind	26	8		
	Coal	1	0½	336	0½
	Clunch, bind, coal (7½ in.)	78	9½		
	Stone bind and rock	31	1		
	Coal	2	4		
	Grey clunch and stone bind	16	7		
	Coal	8	4	473	2
	Clunch, bind, ironstone	37	3		
	Coal	1	10	512	3
	Bind with ironstone, stone bind, thin coals	163	9½		
	Coal	2	10	678	10½
	Clunch	2	1		
	Stone bind and rock	20	1½		
	Coal, Deep Soft	5	0	706	1
	Bind and stone bind, ironstone ...	36	9½		
	Coal, Deep Hard	5	7½	748	6
	Clunch, bind, ironstone	36	7		
	Coal, Piper	3	4	788	5
	Clunch	0	5		

No. 8.

Clipston Boring.

1-inch Map (N.S.) 142 ; 6-inch Map, Notts., 47 N.W.
Lat. 52° 53′ 30″ N ; long. 1° 3′ 5″ W.
Communicated by Mr. E. Parry.
Height above O.D. 190 ft.
[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
	Soil		7	0		
	Sandy clay and boulders		4	0	11	0
Trias ...	Keuper Marl.	Clay and red marl	46	0		
		Hard red marl with five bands of gypsum	35	0		
		Hard red marl with gypsum ...	39	0		
		Grey sandstone	2	0		
		Hard red marl with gypsum, layers of sandstone at base ...	60	0		
		Red marl, gypsum, and grey rock	46	0		
		Hard grey rock, red marl, and gypsum	16	0		
		Friable red marl and gypsum ...	30	0		
		Hard grey rock, with red and blue marl	28	0		
		Hard grey rock	8	0		
		Red marl...	3	0		
		Hard grey rock	2	0		
		Hard red and blue marl with gypsum	154	0		
		Hard red and blue marl and hard grey rock.	40	0	520	0

Clipston Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Trias—*cont.*	Keuper Waterstones.	Red and blue marl, gypsum, and grey rock	90	0		
		Sandy marl and gypsum, mixed with red and grey sandstone	38	0		
		Sandy marl, gypsum, and sandstone	12	0		
		Red and blue sandy marls, mixed with sandstone	52	0	712	0
	Lower Mottled Sandstone and Bunter Pebble Beds.	Red and grey sandstones, with pebbles	7	0		
		Red and grey sandstone, with pebbles and conglomerate	62	0		
		Red and grey sandstone, with pebbles	67	0		
		Red and grey sandstone	112	0		
		Sandstone conglomerate	10	0	970	0
Coal Measures.		Variegated marly shale	20	0		
		Coloured shaly sandstone	30	0		
		Dark shale	0	10		
		Coal	1	10	1022	8
		Fireclay	7	11½		
		Coal	1	6	1032	1½
		Fireclay	1	0		
		Coal and black shale	1	6	1034	7½
		Fireclay with ironstone nodules	1	6		
		Sandstone	11	6		
		Blue shale	20	0		
		Black shale mixed with coal	2	6	1070	1½
		Fireclay with ironstone	3	0		
		Shale (Marine bed 1129 to 1145 ft.)	75	10½		
		Coal	0	4	1149	4
		Blue shale	5	8		
		Sandy shale and sandstone	9	0		
		Shale	53	0		
		Coal	1	0	1218	0
		Fireclay	2	0		
		Shale	22	3		
		Coal	0	9	1243	0
		Fireclay	11	9		
		Blue shale	2	0		
		Hard blue shaly sandstone	6	0		
		Shale with ironstone	4	0		
		Grey shale	9	0		
		Coal, cannel and fireclay	2	3	1278	0
		Fireclay	6	8		
		Sandy shale and shale with ironstone	58	10		
		Cannel, black shale and coal	4	6	1348	0
		Fireclay and shale	17	0		
		Coal	2	0	1367	0
		Fireclay and shale	23	6		
		Coal	0	6	1391	0
		Fireclay and ironstone	3	0		
		Hard grey rock with spar joints, shale partings	40	0		
		Coal	2	0	1436	0
		Fireclay	8	0		
		Coal	1	6	1445	6
		Fireclay	2	0		
		Shale	61	6		
		Coal	2	6	1511	6

Clipston Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Fireclay	1	0		
	Black shale and coal	0	6		
	Fireclay and shale	2	3		
	Grey and black shale with shells	2	0		
	Shale with ironstone	6	6		
	Coal	0	3	1524	0
	Fireclay and hard sandstone	3	0		
	Grey shale with sandstone	40	0		
	Coal	1	2	1568	2
	Fireclay	2	10		
	Coal	0	8	1571	8
	Fireclay and ironstone	6	10		
	Grey shaly ironstone	12	0		
	Coal	1	6	1592	0
	Fireclay	6	0		
	Hard grey shale	25	0		
	Blue and black shale	2	6		
	Fireclay with ironstone	6	0		
	Shaly sandstone and sandy shale	17	6		
	Grey and black shale	8	3		
	Coal, soft	1	0	1658	3
	Fireclay	8	9		
	Blue shale and ironstone	28	0		
	Coal	0	8	1695	8
	Fireclay	8	4		
	Shale and ironstone	34	0		
	Coal	0	3	1738	3
	Fireclay	5	9		
	Sandstone with black marks	3	6		
	Grey shale and sandy shale	12	6		
	Shale	23	6		
	Hard coarse sandstone	2	6		
	Shale	37	0		
	Black shale	0	3		
	Grey fireclay	2	9	1826	0
	Hard grey shale with plant remains	13	0		
	Sandstone and shaly sandstone	132	0		
	Grey shale	75	0		
	Blue shale with ironstone	59	0	2105	0

No. 9.

Dinnington Main Colliery.

Section in the upcast shaft at the Dinnington Main Colliery.

1-in. Map (N.S.) 100 ; 6-in. Map, Yorks., 296 S.E.

Communicated by Mr. M. Deacon.

Height above O.D. 340 ft.

[Abridged.]

		Thickness. Ft.	In.	Depth. Ft.	In.
	Soil	0	9		
Coal Measures.	Yellow clay	6	7		
	Clay	4	0		
	Black shale	0	4		
	Coal	0	2	11	10
	Blue bind	1	6		
	Grey rock, very jointy	2	9		
	Blue bind	12	7		
	Ironstone	0	6		

Dinnington Main Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Coal and batt...	0	4		
	Clunch	0	11		
	Grey rock, jointy	3	6		
	Streaky grey bind	6	9		
	Coal and batt	1	3		
	Clunch	7	0		
	Grey bind	9	0		
	Coal	0	3	58	2
	Strong stone clunch	2	0		
	Hard rock	11	8		
	Soft blue bind...	3	10		
	Black batt	1	3		
	Strong clunch	5	6		
	Grey bind	20	4		
	Coal	0	5		
	Clunch	0	10		
	Coal	0	1	104	1
	Clunch	1	0		
	Grey bind and rock	6	11		
	Coal	0	2	112	2
	Clunch	5	5		
	Grey rock	4	6		
	Blue bind	16	9		
	Black shale	0	5		
	Ironstone band	0	6		
	Black shale	0	7		
	Strong stone clunch	4	2		
	Grey rock	5	10		
	Black batt with thin streaks of coal...	2	7	152	11
	Light clunch	6	5		
	Grey bind and black shale	14	10		
	Coal and batt	1	5	175	7
	Clunch with small ironstone pebbles	5	7		
	Grey bind with rock bands	17	1		
	Strong grey bind with ironstone bands	18	5		
	Coal	0	4		
	Black batt	1	0		
	Stone clunch	7	9		
	Stone bind and grey rock	16	10		
	Black batt	1	2		
	Clunch	3	9		
	Grey bind	7	6		
	Coal	0	9	255	9
	Strong clunch	6	3		
	Strong grey bind with large ironstone balls	35	2		
	Grey bind and rock band	4	11		
	Coal	0	11	303	0
	Stone clunch	2	8		
	Grey rock and bind, mixed	44	0		
	Coal and batt...	0	3	349	11
	Clunch	1	7		
	Grey rock	6	9		
	Stone bind, very strong	3	7		
	Bind	2	3		
	Black batt	1	1		
	Clunch	1	5		
	Grey rock, stone bind, and grey bind	24	7		
	Grey bind with ironstone bands ...	5	3		
	Coal	0	9	397	2
	Dark clunch with small ironstone balls	4	5		

Dinnington Main Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Strong stone clunch	3	8		
	Clunch	10	10		
	Dark bind	2	1		
	Clunch	3	5		
	Coal and batt	0	6	422	1
	Clunch	5	1		
	Coal	0	3		
	Ironstone band	0	1		
	Coal	0	1		
	Stone clunch	0	7		
	Strong stone bind with layers of rock	15	6		
	Rock	60	6	504	2
	Strong stone bind	14	5		
	Rock	6	0	524	7
	Blue bind	7	0		
	Rock	3	4		
	Strong stone bind	4	0		
	Dark shale	7	5		
	Coal	0	10½	547	2½
	Blue bind	19	8½		
	Rock bind and thin coal	35	2		
	Strong stone bind with ironstone bands	5	6		
	Blue bind with ironstone balls ...	3	10		
	Strong stone bind	15	8		
	Clunch with ironstone balls	9	6		
	Light grey stone bind merging into dark grey stone bind	5	4		
	Grey sandstone, slaty brown colour at base	91	1		
	Coarse brown and white sandstone with balls of reddle ... ... (Treeton Rock, 179 ft. 8 in.)	44	9		
	Cank ... ... (Treeton Rock, 179 ft. 8 in.)	8	4		
	Brown and white sandstone with balls of reddle ... (Treeton Rock, 179 ft. 8 in.)	12	10		
	Brown sandstone ... (Treeton Rock, 179 ft. 8 in.)	4	6		
	White sandstone ... (Treeton Rock, 179 ft. 8 in.)	18	2	821	7
	Blue bind	2	3		
	Black shale	2	1		
	Soft clunch	1	4		
	Stone clunch with balls of reddle ...	4	10		
	Stone bind	21	7		
	Blue bind with ironstone bands and balls	6	5		
	Coal	1	11	862	0
	Stone clunch	4	9		
	Rock	0	11		
	Strong stone bind	6	6		
	Grey rock	2	6		
	Blue bind with ironstone bands ...	10	9		
	Black bind	2	0		
	Light clunch	5	9		
	Grey bind with black partings ...	5	6		
	Stone clunch with ironstone balls ...	3	0		
	Rock	3	0		
	Streaky stone bind	3	6		
	Grey bind with ironstone bands ...	3	11		

Dinnington Main Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Black shale	0	7		
	Dark grey bind	15	8		
	Black shale with streaks of coal	1	1		
	Grey bind with ironstone bands	2	9		
	Coal and batt	0	8	934	10
	Ironstone	0	4		
	Stone clunch	2	4		
	Streaky stone bind	4	4		
	Grey bind with rock partings	24	4		
	Batt	0	4		
	Coal	0	8	967	2
	Batt	0	1		
	Clunch with ironstone balls	2	6		
	Coal	1	1	970	10
	Clunch	1	6		
	Stone bind	11	5		
	Coal 5 in, ironstone 3 in.	0	8	984	5
	Batt	0	5		
	Stone clunch	3	8		
	Grey bind	7	9		
	Stone clunch with ironstone balls	6	5		
	Stone bind	4	8		
	Grey rock and cank	0	10		
	Grey bind	21	7		
	Coal (dirty)	0	10	1,030	7
	Dark clunch with ironstone balls	0	6		
	Strong stone bind	16	4		
	Ironstone	0	2		
	Coal, very soft	0	9	1,048	4
	Streaky stone bind with streaks of coal	2	2		
	Stone bind and rock	16	6		
	Grey bind	20	7		
	Dark bind with ironstone bands	7	0		
	Coal	1	2	1,095	9
	Stone clunch	6	0		
	Grey bind	6	7		
	Dark bind	2	0		
	Clunch with ironstone balls	3	10		
	Stone bind	9	2		
	Coal, dirty	0	4		
	Dark clunch	1	2		
	Coal	0	8	1,125	6
	Stone clunch	3	2		
	Grey bind and stone bind	57	11		
	Dark bind	2	0		
	Stone clunch	1	0		
	Dark bind, faulty } ? Mansfield	17	0		
	Cank stone, very hard } Marine Bed.	4	6		
	Strong grey stone bind	6	7		
	Coal	0	4	1,218	0
	Clunch with small ironstone balls	2	5		
	Grey rock, Wooley Edge Rock	162	4		
	Clunch, coal and rock mixed	5	0		
	Grey bind	12	8		
	Coal and batt	0	6	1,400	11
	Stone clunch	9	7		
	Grey bind with ironstone bands	16	1		
	Strong stone bind	22	8		
	Batt with streaks of coal	1	5		
	Light clunch	3	6		
	Bind and clunch with ironstone balls	9	5		

Dinnington Main Colliery—*continued.*

		Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Coal Measures —*cont.*	Coal	0	2½	1,463	9½
	Clunch with ironstone balls	2	3½		
	Dark bind	7	6		
	Coal, Wathwood	2	11	1,476	6
	Brown clunch	2	9		
	Grey rock and bind in layers	38	11		
	Ironstone	0	3½		
	Dark bind	1	3½		
	Strong grey bind with ironstone bands	26	1		
	Coal 2 ft. 4¼ in. with several partings 2 ft. 6¼ in.	4	11	1,550	9
	Clunch	2	4		
	Coal 4 in., dirt parting 6 in.	0	10		
	Clunch	3	4		
	Coal	0	2	1,557	5
	Clunch	0	8		
	Hard rock and strong stone bind	18	0		
	Dark bind	12	2		
	Coal, clean and bright	1	8	1,589	11
	Stone clunch	1	7		
	Grey rock and stone bind	22	11		
	Grey and dark bind with ironstone patches	8	7		
	Coal 1 ft. 10 in., dirt parting 3 in.	2	1	1,625	1
	Stone clunch with cank balls	3	8		
	Stone bind and rock	38	8		
	Coal 2 ft. 2½ in., parting 1 ft. 6 in.	3	8½	1,671	1½
	Strong stone clunch	5	0		
	Bind with ironstone and clunch mixed	56	10½		
	Coal 2 ft. 10 in., dirt parting 2 in.	3	0	1,736	0
	Clunch	0	10		
	Batt	0	1½		
	Clunch with ironstone balls	4	5½		
	Bind and stone bind with ironstone	79	3		
	Coal	0	3	1,820	11
	Stone clunch with ironstone balls	2	1		
	Grey bind	13	1		
	Coal	0	9	1,836	10
	Stone clunch	4	10		
	Grey bind	1	4		
	Batt with streaks of coal	0	6		
	Coal 1 ft. 5 in., dirt parting 1 in.	1	6	1,845	0
	Stone clunch	1	3		
	Rock, bind and stone bind with ironstone	77	5		
	Black shale	1	0		
	Stone clunch	0	5		
	Stone bind	11	9		
	Rock	0	9		
	Clunch with a few patches of coal	5	5		
	Stone bind with ironstone balls	9	10		
	Clunch (dirty) with ironstone balls	4	1		
	Strong stone bind	9	0		
	Grey rock	1	10		
	Very strong stone bind	0	10		
	Grey rock, very hard and close grained	16	3		
	Rock with black streaks	4	8		
	Coal 9 in., clunch parting 1 ft. 4 in.	2	1		
	Grey bind with ironstone balls	4	2		
	Clod	0	7¾		

Dinnington Main Colliery—*continued.*

		Thickness. Ft.	In	Depth. Ft.	In.
Coal Measures —*cont.*	Coal, Barnsley	4	3¼	2,000	8
	Stone clunch	5	1		
	Grey bind with ironstone balls ...	9	0		
	Strong stone clunch	4	10		
	Stone bind	17	3		
	Coal	0	6	2,037	4
	Clunch	8	10		
	Grey rock	0	11		
	Stone clunch with ironstone bands ...	4	2		
	Stone bind with ironstone balls ...	30	9	2,082	0

No. 10.

Edwalton Boring.

1-in. Map (N.S.) 126 ; 6-in. Map, Notts., 42 S.E.

Communicated by Mr. T. Potter.

Height above O.D. 95 ft.

[Abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
	Black soil and sandy loam		9	0	9	0
Trias ...	Keuper Marl.	Red marl and gypsum	16	8		
		Grey shaly sandstone	8	0		
		Red and grey marl, sandstone, with gypsum	34	6		
		Red and grey marl, sandy marl, with gypsum	290	1¼		
		Red and grey sandstone ...	13	4¾		
		Red sandy marl, with gypsum...	27	4	399	0
	Keuper Waterstones.	Red marl and sandy marl...	18	8½		
		Red and grey sandstone ...	11	3		
		Grey conglomerate ...	0	6		
		Red, brown and grey sandstone	20	2½	449	8
	Lower Mottled Sandstone and Bunter Pebble Beds.	Brown and grey sandstone, with pebbles...	158	1		
		Conglomerate	15	0		
		Red and grey mottled sandstone	77	3		
		Conglomerate	4	0	704	0
Coal Measures.	Dark purple and grey mottled marl...		24	0½		
	Shaly sandstone and blue bind ...		25	6		
	Coal / Parting / Coal — Dunsil	... ...	2	5		
		... ...	0	2		
		... ...	0	3	756	4½
	Clunch and bind, ironstone		24	6		
	Black shale		0	5		
	Coal		1	6		
	Fireclay		0	1½		
	Coal, Waterloo		1	11	784	10
	Shaly bind and ironstone		18	8		
	Coal		1	5		
	Clunch, bind, ironstone		114	7		
	Coal		1	8		
	Clunch, bind, ironstone		9	4		
	Coal		1	2		

Edwalton Boring—*continued.*

		Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
Coal Measures —*cont.*	Clunch, bind, ironstone	47	10		
	Shell bed with ironstone	2	3		
	Coal	0	9		
	Fireclay	2	1		
	Coal	0	8	985	3
	Clunch, bind, ironstone	23	10		
	Dark shale with fossils	1	7		
	Cank	0	7½		
	Blue bind with ironstone	39	7½		
	Dark bind ironstone with shells ...	5	9		
	Coal	0	8	1,057	4
	Clunch, bind, stone bind	88	11½		
	Coal, Ell	3	0	1,149	3½
	Clunch, bind, ironstone	36	1		
	Coal, Deep Soft	3	4	1,188	8½
	Clunch	4	11½		
	Sandstone and stone bind	78	3½		
	Very black shale	1	2		
	Coal, Piper	2	10	1,275	11½
	Clunch and bind	24	11½		
	Coal	0	6½		
	Clunch	4	6½		
	Coal	0	9		
	Clunch and shale (56 ft. 2 in.) ...	64	5		
	Coal, Tupton	3	1½	1,374	3½
	Dark clunch and ironstone	7	1		
	Coal	2	1		
	Parting } Tupton Three Quarters	0	0½		
	Coal	0	3	1,383	9
	Clunch, bind, stone bind, ironstone...	70	7		
	Coal, hard	0	8		
	Blue and dark shale	10	3½		
	Coal	1	3		
	Stone bind, blue bind, ironstone ...	26	7½		
	Coal, soft	3	3½	1,496	5½
	Clunch	3	6½	1,500	0

No. 11.

Gedling Colliery.

1-in. Map (N.S.) 126 ; 6-in. Map, Notts., 38 S.E.

Communicated by Mr. E. Parry.

Height above O.D. 185 ft.

[Abridged.]

			Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
	Sandy soil		7	3	7	3
Trias ...	Keuper Waterstones.	Red marl and green clay [alternating layers]	13	9		
		Soft rocky marl...	1	5		
		Hard red rock	2	7		
		Red and grey sandstone ...	2	4		
		Rocky marl with traces of white rock	7	1		
		Red and white rock, in beds ...	8	8		
		Red and grey marly rock ...	30	4		
		Conglomerate	2	10	76	3

Gedling Colliery—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Trias—*cont.*	Bunter Pebble Beds	Strong yellow sandstone with pebbles	281	10		
		Strong red sandstones with grey bands	43	0		
		Grey rock band	0	9		
		Red sandy marl with beds of clay	2	2		
		Sharp red sandstone with pebble beds	10	1		
		Coarse red sandstone	16	1		
		Red and grey sandstones in thin bands	6	2		
		Coarse white sandstone	9	0		
		Grey sandstone, pebble bed	1	3		
		White stone	0	11		
		Red and grey ground	13	11	461	5
Permian		Strong grey ground	46	1		
		Grey grit [Permian Breccia]	0	8	508	2
	Etruria Marls.	Red rock, mixed ground	19	9		
		Grey stone band	2	1		
		Mixed ground, yellowish	5	0		
		Red ironstone	3	0		
		Red shale and ironstone	2	6		
		Red rocks, mixed ground	19	10		
		Pink bind	16	9		
		Mixed ground, red, grey, and hacklish	24	11		
		Red and blue shale	5	6		
		Mixed ground	30	3	637	9
		Black batt and coal	0	9		
		Grey binds	11	11		
		Batt	0	1		
		Coal	1	0		
		Dirt	0	3		
		Coal	0	2½		
		Dirt	0	2½		
		Coal	0	6½	652	8½
		Clunch	3	8		
Coal Measures.		Stone clunch	0	7½		
		Strong grey clunch	11	9		
		Grey rock	5	8		
		Grey bind	9	6		
		Black shale	1	2½		
		Coal	0	4	685	5½
		Black batt	0	4½		
		Binds, shale and clunch	12	3		
		Black batt	0	2		
		Coal	0	6½	698	9½
		Clunch	4	1½		
		Bind and ironstone	9	1		
		Coal	1	6	713	6
		Clunch	2	11		
		Bind and clunch	20	5		
		Grey sandstone	4	9		
		Grey and dark bind	8	4		
		Grey rock	18	10		
		Grey and blue bind	6	8		
		Black bind	0	6		
		Coal	1	1	777	0
		Clunch	2	7		
		Stone clunch with ironstone	3	6		

Gedling Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Grey and dark binds	42	0		
	Coal, bright	0	6	825	7
	Black batt	0	3		
	Coal and batt	0	4		
	Clunch	4	4		
	Grey bind and ironstone	7	6		
	Dark stony bind	4	10		
	Dark bind [Marine bed]	1	8		
	Coal	1	7	846	1
	Grey clunch, strong	5	0		
	Grey bind and clunch...	16	10		
	Grey stone bind and rock	7	6		
	Dark bind	10	11		
	Clunch	9	5		
	Bind and stone bind	31	3		
	Dark bind and ironstone	2	2		
	Strong stone clunch	1	1		
	Strong brown stone	0	7½		
	Coal	1	3½	932	2
	Clunch	1	11		
	Rock and stone bind	7	7		
	Grey and black bind	9	0		
	Dirt	0	3		
	Coal	2	10	953	9
	Clunch	3	8		
	Stone bind, grey and dark bind ...	19	11½		
	Coal	0	10	978	2½
	Black batt	0	4½		
	Clunch	15	7		
	Batt and clunch	7	11		
	Coal and batt...	0	4		
	Clunch	0	5		
	Coal	0	7½	1,003	5½
	Dark clunch	3	7½		
	Clunch and grey bind	6	11		
	Dark bind [Marine bed]	7	7		
	Black hard stone [Marine bed] ...	0	11	1,022	6
	Dark bind	2	6		
	Coal	0	10½	1,025	10½
	Grey clunch	10	10½		
	Grey and blue bind with ironstone ...	26	10		
	Coal	1	10	1,065	5
	Grey clunch	9	0		
	Coal	0	1½		
	Rock bind with coal streaks	1	8½		
	Batt with coal	2	2		
	Dark clunch	2	3		
	Coal (dirty)	1	0		
	Coal (bright)	0	9	1,082	5
	Clunch and clod	5	1		
	Grey bind	18	1		
	Black bind	1	0		
	Rotten darker bind	1	9½		
	Coal, High Hazles	3	9	1,112	1½
	Hard clunch	1	2½		
	Bind and ironstone	6	10		
	Brown stone	0	6		
	Coal	0	4½		
	Grey clunch and bind...	10	11		
	Coal	0	7½	1,132	7
	Grey clunch	1	8		

Gedling Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Grey rock and bind	22	5½		
	Black bind	1	3		
	Black batt	0	7½		
	Coal	2	2	1,160	9
	Dark clunch	1	5		
	Grey and dark bind	9	8		
	Bat and dark bind	2	3		
	Coal	1	0		
	Dirt	0	5		
	Coal	1	3	1,176	9
	Coal and batt	0	7		
	Stone clunch	2	9		
	Bind and stone bind	9	5		
	Coal	0	5½		
	Batt	0	4		
	Clunch	4	8½		
	Stone bind and rock	31	1½		
	Coal	2	9½	1,228	11
	Fireclay	0	0½		
	Coal	0	8	1,229	7½
	Soft clunch and batt	1	2½		
	Blue bind	4	0		
	Sandstone rock	7	2		
	Grey bind and ironstone	9	5		
	Coal and batt	0	4		
	Clunch with ironstone balls	2	5		
	Coal	1	1	1,255	3
	Clunch and clunchy binds	10	6		
	Grey rocks and binds	4	10		
	Dark bind	0	6		
	Coal	0	2½		
	Clunch	1	0½		
	Grey rock and bind	17	8		
	Black shale, coal and batt	0	6		
	Dark and stone clunch	2	4		
	Stone binds and rock	10	8		
	Grey bind and ironstone	7	7		
	Black shale and ironstone balls	0	9		
	Coal	0	2		
	Soft clunch	1	5		
	Dark grey sandy binds with ironstone	2	7		
	Grey bind with ironstone	2	2		
	Grey stone bind	3	8		
	Grey bind	7	4		
	Grey rock with darker streaks	0	3		
	Grey bind	10	8		
	Coal	1	2½	1,341	3½
	Black batt	0	3½		
	Grey bind with ironstone balls	6	2		
	Grey bind	3	6		
	Black shale	1	5		
	Dark hard sandy bind	0	9		
	Dark rotten bind	1	11		
	Good grey bind	11	1		
	Softer bind	2	0		
	Coal	0	5		
	Clod	2	3¼		
	Coal	1	0¾	1,372	2
	Clod full of ironstone balls	2	9		
	Coal, Top Hard (*see* p. 56)	2	11	1,377	10
	Grey clunch	5	0	1,382	10

No. 12.

Haxey (Idlestop) Boring.

1-in. Map (N.S.) 86 ; 6-in. Map, Yorks., 25 S.W.
Lat. 53° 28′ 30″ ; Long. 0° 54′ 11″.
Height above O.D. 18 ft.
Abridged from account in *Trans. Fed. Inst. Min. Eng.*, vol. xii, 1896–97, pp. 518–522.

		Thickness. Ft.	In.	Depth. Ft.	In.
	Soil	1	6	1	6
	Sand and sandy clay	30	0		
	Sand and gravel	0	6	32	0
Trias	Red and blue marl	3	0		
	Red and blue marl with gypsum	10	6		
	Grey sandstone	1	0		
	Grey limestone	1	6		
	Red and blue marl with gypsum	89	7		
	Red and grey sandstone, with beds of marl	533	1		
	Red sandstone	75	6		
	Red sandstone with pebbles	271	11		
	Red sandstone with beds of marl	162	5	1,180	6
Permian	Red marl with gypsum	7	0		
	Anhydrite	8	10		
	Red marl with gypsum	42	3		
	Fine grey sandstone with gypsum	30	10		
	Grey limestone	53	0		
	Blue and red marl with gypsum	132	9		
	Grey limestone	273	1	1,728	3
	Mottled sandy shale	5	0		
	Mottled shale	4	0	1,737	3
Coal Measures.	Red and grey sandstone, *Rotherham Red Rock*	93	9	1,831	0
	Blue shale	1	0		
	Coal	1	2	1,833	2
	Fireclay	4	6		
	Black shale	1	6		
	Shale	17	0		
	Coal and shale, mixed	0	5		
	Blue shale	22	3		
	Coal	0	10	1,879	8
	Black shale	0	2		
	Fireclay, sandy	19	0		
	Blue sandy shale	13	0		
	Blue rock	7	6		
	Dark blue shale	2	6		
	Grey fireclay	1	7		
	Coal, Shafton	3	1	1,926	6
	Grey fireclay	1	8		
	Grey sandstone	7	0		
	Dark blue shale	6	10		
	Dark blue shale, with ironstone	9	1		
	Grey sandy shale and sandstone	24	5		
	Coal	0	8	1,976	2
	Rotten grey fireclay	13	5		
	Blue shale with ironstone, fine-grained sandstone, and fireclays	207	10		
	Black shale containing gas	0	6		
	Coal, Bagshaw	1	7	2,199	6
	Fireclay	9	6		
	Grey sandstone, coarse grained at base (*Oaks Rock.*)	39	9		
	Blue sandy shale (*Oaks Rock.*)	1	6		
	Coarse grey sandstone (*Oaks Rock.*)	52	4	2,302	7

Haxey (Idlestop)—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Blue sandy shale	16	10		
	Dark shale	4	0		
	Fireclay	3	0		
	Sandy shale and sandstone	46	0		
	Grey fireclay	20	0		
	Black and grey shale	0	11		
	Coal, Swinton Pottery, 3 in. shale parting	3	9	2,397	1
	Sandy fireclay	1	4		
	Fine grained sandstone	70	9		
	Black shale	1	8		
	Coal	1	3	2,472	1
	Fireclay	11	7		
	Shaly sandstone	15	0		
	Fireclay, with balls of ironstone ...	4	9		
	Black shale, with balls of ironstone...	17	11		
	Black shale and ironstone	14	6		
	Grey sandstone, coarse and gritty ... (*Wooley Edge Rock.*)	11	7		
	Sandy shale ... (*Wooley Edge Rock.*)	40	8	2,588	1
	Shale	5	6		
	Coal	0	10	2,594	5
	Fireclay	3	2		
	Shale	22	6		
	Coal, Wathwood	0	11	2,621	0
	Fireclay	1	0		
	Sandy shale and shaly sandstone ...	25	2		
	Shale with ironstone	20	6		
	Coal, Two Feet	0	10	2,668	6
	Grey fireclay	1	0		
	Blue shale with ironstone	38	9		
	Black shale	0	8		
	Coal, Abdy	1	0	2,709	11
	Shale with balls of ironstone ...	19	4		
	Grey sandstone	67	2		
	Shale and shaly sandstone	52	0		
	Coal, Low Beamshaw	1	0	2,849	5
	Shale and shaly sandstone	38	7		
	Coal, Kent's Thin [entered as black shale]	1	0	2,889	0
	Sandy shale, with ironstone	42	6		
	Sandstone and sandy shale, *Kent's Thick Rock*	72	3		
	Black shale	4	5		
	Coal 2 ft. 10 in.; shale 1 ft. 7 in., Kent's Thick Coal	4	5	3,012	7
	Strong fireclay...	1	0		
	Sandy shale, shale, and sandstone ...	73	10		
	Grey sandstone	19	8		
	Sandy shale	13	9		
	Shale with ironstone	12	8	3,135	6
	Coal ... (Barnsley Soft) ...	1	0		
	Dark fireclay (Barnsley Soft) ...	3	6		
	Coal ... (Barnsley Soft) ...	4	1		
	Coal and dirt (Barnsley Soft) ...	0	4		
	Coal ... (Barnsley Soft) ...	0	4	3,142	9
	Fireclay	2	0		
	Blue shale with ironstone	36	3		
	Coal, Barnsley Hard	4	7	3,185	7
	Fireclay	4	2		
	Shaly sandstone	5	6	3,195	3

No. 13.

Highfield Boring, Beeston.

1-in. Map (N.S) 126 ; 6-in. Map, Notts., 42 S.W.

Abridged from MS. in Survey Office.

Height above O.D. 84 ft.

		Thickness. Ft.	In.	Depth. Ft.	In.
	Alluvium	21	1	21	1
Trias ...	Red sandstone...	234	0		
	Grey sandstone and clay	2	0	257	1
Coal Measures.	Bind with ironstone	39	2		
	Coal	2	2	298	5
	Bind	17	0		
	Coal	2	6	317	5
	Bind with ironstone	119	8		
	Coal	0	7½	437	8½
	Bind, sandstone, bind with ironstone	76	10		
	Stone bind	41	8		
	Coal, Deep Soft	3	0	559	2½
	Clunch	1	6		
	Dark bind and cannel...	2	6		
	Bind	9	3½		
	Stone bind	24	0		
	Bind with ironstone	13	4		
	Coal, Deep Hard	6	2	616	0

No. 14.

Maltby.

Section in No. 2 Shaft at the Maltby Main Colliery.

1-in. Map (N.S.) 101 ; 6-in. Map, Yorks., 291 S.W.

Communicated by Mr. M. Deacon.

Height above O.D. 258·76 ft.

			Thickness. Ft.	In.	Depth. Ft.	In.
	Made ground and soil		2	0	2	0
Permian ...	Marl Slates and Lower Magnesian Limestone.	Rubble limestone	4	6		
		Limestone with blue clay partings	15	0		
		Hard limestone	76	10		
		Honeycombed limestone with gypsum	19	0		
		Grey limestone, laminated ...	29	2		
		Dark grey limestone... ...	10	11		
		Red and blue marl, with rolls of stone clunch and a roll of very soft sandstone ...	12	2		
		Hard grey limestone... ...	6	7	176	2
Coal Measures.	Red and grey sandstone with patches of marl [Etruria Marls]		31	7	207	9
	Grey bind		15	10		
	Coal and black shale, mixed... ...		2	0		
	Grey bind		12	4		
	Coal		0	7	238	6
	Clunch		3	7		
	Grey bind		5	7		
	Clunch with a roll of sandstone ...		19	7		
	Grey bind with ironstone bands ...		5	6		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Coal and batt	0	3½		
	Clunch	2	2½		
	Grey bind with ironstone pebbles ...	14	0		
	Dark bind	3	6		
	Clunch with ironstone pebbles ...	2	6		
	Coal	0	3	295	6
	Clunch with rolls of stone clunch ...	6	3		
	Grey sandstone, very hard	15	6		
	Grey bind	8	11		
	Coal and batt	0	1½		
	Clunch	1	11½		
	Very hard grey sandstone	7	10		
	Clunch	4	5		
	Hard dark grey sandstone	3	6		
	Strong grey stone with ironstone bands	7	0		
	Ironstone	0	1		
	Grey bind with ironstone bands ...	2	10		
	Coal 8 in., dirty coal 4 in.	1	0	354	11
	Strong clunch	1	0		
	Grey sandstone, very hard	38	2	394	1
	Grey bind with ironstone binds ...	6	5		
	Coal	1	5	401	11
	Clunch with ironstone pebbles ...	4	7½		
	Coal and batt	0	8½		
	Clunch with ironstone pebbles ...	5	0		
	Stone clunch with ironstone pebbles	3	9		
	Grey sandstone	1	5		
	Grey bind	3	11		
	Stone bind with cank bands and balls	11	0		
	Coal	0	7	432	11
	Clunch with ironstone pebbles ...	4	7		
	Black shale	0	3		
	Clunch with balls of ironstone ...	18	5		
	Coal	0	10	457	0
	Clunch with ironstone pebbles ...	3	9		
	Very hard sandstone	100	11	561	8
	Dirty coal	0	4	562	0
	Dark clunch with ironstone pebbles...	2	1		
	Grey sandstone rock	2	9		
	Grey bind with ironstone bands ...	3	10		
	Clunch with ironstone pebbles ...	2	5		
	Grey sandstone rock with partings ...	2	7		
	Strong grey bind with ironstone ...	4	3		
	Grey rock, full of partings	8	4		
	Strong stone bind	8	1		
	Black shale	1	9		
	Clunch	1	4		
	Ironstone	1	1		
	Grey bind	8	8		
	Coal	0	6	609	8
	Stone clunch	3	7		
	Grey bind with ironstone bands ...	8	0		
	Coal	0	4	621	7
	Strong clunch with ironstone pebbles	6	6		
	Hard grey rock	1	4		
	Strong grey bind with ironstone bands and balls	9	5		
	Dark bind	0	4		
	Clunch with ironstone balls	5	1		
	Strong stone bind	9	3		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Hard rock with partings	6	11		
	Strong stone bind with large ironstone balls	2	7		
	Grey sandstone	158	5	821	5
	Cannel	0	2		
	Coal, clean, bright	2	0		
	Dirt	0	2		
	Coal, clean, bright	0	8	824	5
	Clunch with ironstone balls	3	6		
	Sandstone rock	1	4		
	Strong grey bind	4	3		
	Grey sandstone rock, streaky ...	0	8		
	Grey bind with ironstone balls ...	8	8		
	Dark bind	0	9		
	Clunch	4	5		
	Grey bind with ironstone bands ...	6	10		
	Dark bind	1	5		
	Clunch with ironstone balls	1	11		
	Grey bind with ironstone bands and balls	8	5		
	Coal	0	9	867	4
	Stone clunch	4	5		
	Strong grey bind with ironstone bands and balls	19	5		
	Dark bind	0	8	891	10
	Grey sandstone	83	1	974	11
	Coal [? Shafton]	1	4½	976	3½
	Dark clunch with batt mixed ...	1	5½		
	Stone clunch	2	9		
	Grey sandstone	105	1	1,085	7
	Black shale with streaks of coal ...	0	3		
	Strong dark grey bind	2	2		
	Beddy rock	8	0		
	Strong grey bind with ironstone bands	7	2		
	Coal	0	3	1,103	5
	Clunch with ironstone balls	7	7		
	Strong grey bind	10	9		
	Grey rock	1	3		
	Strong grey bind	17	9		
	Clunch with ironstone balls	5	6		
	Stone bind with ironstone balls ...	11	8		
	Clunch with ironstone balls	10	2		
	Black shale	0	7		
	Coal	0	10	1,169	6
	Stone clunch	1	5		
	Hard grey rock	17	10		
	Grey bind with bands of rock ...	8	0		
	Grey bind with ironstone bands (Marine Bed)	10	11	1,207	8
	Coal	1	8	1,209	4
	Stone clunch	5	5		
	Clunch	6	4		
	Coal	0	2	1,221	3
	Clunch	3	6		
	Sandstone rock with bands of bind...	12	3		
	Grey bind with ironstone balls ...	12	9		
	Coal	0	4	1,250	1
	Clunch	5	11		
	Hard stone bind	32	2		
	Very hard close-grained rock ...	8	7		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft	In
	Beddy rock	15	2		
	Hard sandstone	22	8		
	Rock, coal, bind, clunch, very faulty	8	6		
	Sandstone and bind, faulty	24	10		
	Strong stone bind with rock patches	10	3		
	Grey bind with ironstone bands ...	12	11		
	Coal	1	7	1,392	8
	Dark bind with ironstone	0	6		
	Stone clunch	3	3		
	Beddy rock	14	2		
	Grey bind with ironstone bands ...	7	3		
	Black shale and ironstone	1	5		
	Clunch	1	4		
	Bastard stone clunch	3	0		
	Clunch with ironstone balls	5	0		
	Strong grey bind with ironstone bands and balls	37	6		
	Coal	0	10	1,466	11
	Stone clunch	3	5		
	Hard grey rock	2	5		
	Strong grey bind with ironstone balls	3	3		
	Clunch with ironstone balls	4	0		
	Strong bind with rock partings ...	20	5		
	Coal	1	0		
	Dirt	0	8		
	Coal	0	10	1,502	11
	Batt	0	6		
	Stone clunch	5	0		
	Grey bind with ironstone bands ...	10	0		
Coal Measures —*cont.*	Coal	0	4	1,518	9
	Clunch	3	11		
	Stone bind with ironstone	8	9		
	Hard grey rock with cank mixed ...	27	6	1,558	11
	Grey bind with ironstone bands ...	2	8		
	Dark bind with ironstone bands ...	1	1		
	Grey bind with ironstone bands ...	1	6		
	Dark bind	2	0		
	Stone bind	3	8		
	Coal	0	8		
	Light clunch	1	2		
	Black clunch and batt mixed ...	3	0		
	Grey bind with ironstone bands ...	6	4		
	Coal	0	7	1,581	7
	Clunch with ironstone balls	4	4		
	Light coloured rock	9	3		
	Dark grey bind	1	0		
	Stone bind with rock bands	15	9		
	Grey bind with ironstone bands ...	14	11		
	Dark bind with ironstone	1	7		
	Coal	2	0	1,630	5
	Light brown clunch with ironstone pebbles	2	0		
	Stone clunch	5	6		
	Strong streaky bind	10	11		
	Bluish bind	9	3½		
	Very hard ironstone	0	2		
	Coal	1	4	1,659	7½
	Dark clunch	1	3½		
	Stone clunch	1	6		
	Strong stone bind with bands of rock	17	0		
	Stone bind	9	6		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Strong streaky stone bind	28	4	1,717	3
	Grey bind with ironstone balls ...	6	0		
	Dark greyish-blue shale with hard cank balls (Mansfield Marine Bed, p. 20)	19	0½		
	Very hard greyish-blue limestone cank	1	0	1,743	3½
	Coal and batt...	0	3½	1,743	7
	Light brown clunch with ironstone pebbles	3	1		
	Hard stone clunch	5	3		
	Stone bind with ironstone bands and balls	9	7		
	Batt and clunch with streaks of coal	0	8		
	Clunch with ironstone pebbles ...	5	0		
	Stone bind	48	1		
	Stone bind with rock bands	16	4		
	Stone bind	13	7		
	Rock, clunch, bind and coal, faulty...	18	2		
	Coal	0	1½		
	Clunch	5	11½		
	Dark blue bind with ironstone bands and small cank balls (Marine Bed)	18	8	1,888	1
	Rock and stone bind	21	7		
	Dark bind, shaly	0	4		
	Grey bind	3	9½		
	Coal	0	4	1,914	1½
	Strong stone clunch with ironstone balls	3	5½		
	Clunch	13	6		
	Strong sandy grey bind	37	1		
	Coal	0	7	1,968	9
	Light and dark clunch with ironstone balls	6	10		
	Dark strong bind with ironstones ...	9	2		
	Coal, Meltonfield or Wathwood	2	3	1,987	0
	Brown clunch	1	2		
	Hard stone clunch	3	7		
	Strong stone bind with rolls of rock and very hard cank...	16	1		
	Grey bind with ironstone bands ...	6	6		
	Very dark bind	4	6		
	Gannister	2	1		
	Batt with streaks of coal	0	8		
	Gannister	1	10		
	Grey and dark bind with ironstone bands...	32	11		
	Coal, bright ... (Two Foot)	1	0		
	Dirt ... ... (Two Foot)	0	1		
	Coal, bright ... (Two Foot)	0	2		
	Dirt ... ... (Two Foot)	0	1½		
	Coal, bright ... (Two Foot)	0	1½		
	Dirt ... ... (Two Foot)	0	1		
	Coal, hards ... (Two Foot)	0	9		
	Dirt ... ... (Two Foot)	0	1		
	Coal, bright ... (Two Foot)	0	6½	2,059	3½
	Clunch with ironstone nodules ...	1	3		
	Coal	0	2½		
	Clunch	1	4		
	Stone bind with ironstone balls ...	8	4		
	Coal	0	2		
	Dark clunch with ironstone pebbles...	1	8		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Stone clunch with hard cank balls ...	7	4		
	Stone bind	3	2		
	Cank	3	1		
	Stone bind with ironstone	9	2		
	Dark bind	8	6		
	Dark bind with balls of pyrites (Marine Bed)	6	8		
	Bastard cannel	1	11		
	Cannel Coal } Abdy ... ... {	3	7¼		
	Coal } {	0	4¾	2,116	1
	Stone clunch	2	6		
	Strong stone bind	13	0		
	Grey bind with ironstone	8	0		
	Bastard cannel and dark bind ...	4	0		
	Coal, bright, Beamshaw	2	5	2,146	0
	Stone clunch	4	4		
	Clunch with ironstone balls	12	8		
	Coal with pyrites	0	4		
	Batt with streaks of coal	0	11		
	Clunch	4	1		
	Bind	6	0		
	Coal	0	2		
	Clunch	2	0		
	Coal	0	6		
	Clunch and bind with ironstone ...	8	7		
	Coal	0	2		
	Clunch	1	0		
	Strong stone bind	11	10		
	Grey bind with ironstone bands ...	5	8		
	Coal	0	8	2,204	11
	Batt with streaks of coal	2	8		
	Light clunch	1	6		
	Stone bind	17	4		
	Hard white sandstone rock with cank balls	31	9		
	Coal, bright } Kents Thin (of {	1	5		
	Coal and batt } record) ... {	0	4	2,259	11
	Soft clunch	1	9		
	Coal	0	1		
	Hard clunch	1	0		
	Coal	0	1		
	Stone bind	8	1		
	Sandy grey bind with ironstones ...	30	11		
	Strong dark bind	6	6		
	Grey bind with ironstone bands ...	11	8		
	Coal, bright } Kents Thick (of {	1	2		
	Dirt ... } record). {	0	0½		
	Coal, bright } {	1	8½	2,322	11
	Dark clunch	0	2		
	Strong bind with cank balls	8	1		
	Strong stone bind and beddy rock ...	19	7		
	Coal softs {	0	4		
	Do., hards } Kents Thick (of {	0	10		
	Dirt } record). {	0	1¼		
	Coal, bright } {	0	5¾	2,352	6
	Clunch	1	9		
	Rock with cank roll at base over 4 ft. thick	10	1		
	Grey bind with ironstone	9	3		
	Coal, soft	1	3	2,374	10
	Dark clunch	0	9		

Maltby—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Stone clunch	1	5		
	Stone bind with ironstone	13	4		
	Strong dark bind with cank	0	11		
	Strong dark stone bind	14	2		
	Black shale with coal streaks ...	0	3		
	Stone bind	6	3		
	Dark grey bind	12	11		
	Very dark shaly bind...	2	2		
	Dark clunch with cank balls... ...	3	9		
	Dark stone bind	11	9		
	Grey bind with cank balls	1	3		
	Coal	1	11	2,445	8
	Clod with carbonaceous matter and cank balls	6	6¼		
	Coal, Barnsley	8	6¾	2,460	9
	Clunch	2	2½		
	Stone bind with cank ball	7	11½		
	Streaky rock	21	1		
	Coal	1	2	2,493	2

No. 15.

Mansfield Colliery.

Section in No. 2 Shaft, at the Mansfield Colliery (Crown Farm).

1-in. Map (N.S.) 113 ; 6-in. Map, Notts., 23 S.W.

Communicated by Mr. J. P. Houfton.

Height above O.D. 385·86 ft.

[Permian and Trias, abridged.]

			Thickness. Ft.	In.	Depth. Ft.	In.
	Soil		0	10	0	10
Trias ...	Lower Mottled Sandstone and Bunter Pebble Beds.	Sand and pebbles	46	2		
		Mottled sandstone [small pebbles]	40	4		
		Red sandstone	84	10		
		Red marl	5	1		
		Red sandstone with marl partings	28	3		
		Red marl with white sand partings	2	4		
		Red sandstone with marl pockets	76	0	283	10
Permian ...	Red marl with white sand partings...		14	2		
	Magnesian limestone with red marl partings		6	3		
	Limestone and stone marl in layers		4	0		
	Brown limestone		2	6		
	Coarse mottled sandstone		1	0		
	Light brown limestone with small quartz pebbles		5	0		
	Red and white limestone in layers ...		0	6		
	Yellow limestone		16	3		
	Red limestone...		0	11		
	Grey, blue, and brown limestone ...		32	1		
	Blue shales		98	7		
	Breccia		2	11	468	0

Mansfield Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures.	Soft grey rock	27	4		
	Red and blue shales	6	2		
	Red and grey rock	2	6		
	Red and brown shales	1	0		
	Grey and reddish brown sandstone ...	0	6		
	Grey sandstone	1	6		
	Black bind	0	1		
	Soft and hard clunch	16	7		
	Grey bind	6	1		
	Grey rock	8	10		
	Grey bind	0	10		
	Stone clunch	2	3		
	Coal, bright	0	3	541	11
	Dark and grey clunch...	1	6		
	Black bind	0	5		
	Coal, bright	1	2	545	0
	Black and grey clunch	7	11		
	Blue bind	1	11		
	Black bind	0	11		
	Blue bind	0	8		
	Stone clunch	3	6		
	Blue bind	1	0		
	Grey rock	1	3		
	Dark blue bind	1	7		
	Stone bind	3	0		
	Grey rock	1	2		
	Stone bind	3	3		
	Blue bind	4	5		
	Stone clunch [fine-grained sandstone]	2	5		
	Grey rock	0	7		
	Stone bind [micaceous grey marl] ...	0	7		
	Grey cank rock [compact, hard, grey sandstone]	2	6		
	Stone bind [micaceous grey marl] ...	7	2		
	Blue bind [grey marl]	29	4		
	Black bind	0	11		
	Grey clunch	6	7		
	Grey rock	0	8		
	Stone bind	7	1		
	Blue bind	3	2		
	Coal, bright	1	7	638	2
	Stone clunch	4	5		
	Stone bind	4	11		
	Blue bind	4	3		
	Black bind [*Anthracomya phillipsi*]	0	11		
	Blue bind	2	4		
	Black bind	3	0		
	Blue bind and 8-in. band of ironstone	1	4		
	Black bind	0	9		
	Strong clunch	1	10		
	Stone bind	0	11		
	Grey sandstone rock	1	7		
	Stone bind	3	2		
	Grey sandstone	9	2		
	Stone bind	1	2		
	Grey sandstone rock	0	8		
	Blue bind	1	10		
	Black bind [*Anthracomya phillipsi*]	0	10		
	Coal	1	8	682	11
	Clunch	5	11		
	Grey bind	8	3		
	Hard clunch	3	3		
	Stone clunch [hard grey marl] ...	1	10		

Mansfield Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Coal, batt, and soft clunch	0	3		
	Stone clunch [grey sandstone] ...	4	8		
	Grey sandstone	2	10		
	Grey bind	30	8		
	Blue bind	0	9		
	Coal	0	7	741	11
	Clunch	2	8		
	Grey sandstone rock	6	3		
	Stone bind	4	9		
	Blue bind	7	3		
	Black bind [*Anthracomya phillipsi*]	0	7		
	Hard clunch	2	4		
	Grey cank [hard grey sandstone] ...	1	0		
	Grey bind	8	0		
	Grey sandstone rock	3	1		
	Grey bind	1	10		
	Blue bind	2	6		
	Coal 8 in., two clunch partings 11 in.	1	7	783	9
	Clunch	3	8		
	Blue bind	4	5		
	Coal	1	1	792	11
	Clunch	5	10		
	Stone bind	24	6		
	Grey bind	0	8		
	Coal	2	7	826	6
	Clunch	4	8		
	Stone clunch [sandstone]	0	5		
	Grey sandstone rock	0	4		
	Blue bind	3	3		
	Stone bind	4	10		
	Grey sandstone rock	7	4		
	Stone bind	2	9		
	Grey bind	5	0		
	Coal	1	9		
	Clunch	2	7		
	Coal	0	4	859	9
	Clunch	1	10		
	Stone clunch and stone bind... ...	6	6		
	Blue bind	4	10		
	Batt and black bind	3	7		
	Clunch	0	5		
	Stone clunch [sandstone]	0	11		
	Grey sandstone rock	2	1		
	Stone bind	1	6		
	Dark blue bind	13	5		
	Coal	1	0	895	10
	Clunch	1	4		
	Stone clunch [sandy marl]	2	1		
	Grey sandstone rock	1	9		
	Blue bind	1	3		
	Batt	0	1		
	Clunch	1	4		
	Blue bind	5	0		
	Coal	1	4	910	0
	Clunch	5	6		
	Grey bind and clunch mixed... ...	16	6		
	Stone bind	8	9		
	Grey sandstone rock and cank mixed	13	4		
	Dark blue shale	5	5		
	Blue bind { Mansfield Marine	36	5		
	Blue cank { Bed ... ... } ...	1	7	997	6
	Dark blue bind	2	4		
	Coal	0	7	1,000	5

Mansfield Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Clunch	5	3		
	Grey stone bind and cank	12	10		
	Dark blue bind	17	11		
	Light stone clunch [grey marl] ...	3	1		
	Dark blue bind	3	5		
	Coal	0	11	1,043	10
	Clunch	1	7		
	Grey stone bind	7	8		
	Blue bind	1	1		
	Black bind with coal streaks... ...	2	11		
	Coal	0	6	1,057	7
	Clunch	4	3		
	Blue bind	19	3		
	Stone bind	1	2		
	Coal	0	4	1,082	7
	Stone clunch [grey marl]	5	0		
	Stone bind	10	10		
	Coal	0	6	1,098	11
	Clunch	4	5		
	Strong blue bind	8	1		
	Coal	0	9	1,112	2
	Clunch	6	11		
	Stone bind and grey sandstone rock	39	3		
	Black bind	1	6		
	Coal, Clowne	2	8	1,162	6
	Light clunch	3	9		
	Blue bind	4	0		
	Black bind	3	6		
	Coal and batt...	1	1	1,174	10
	Clunch	8	0		
	Grey bind	58	10		
	Coal	2	2	1,243	10
	Stone clunch [sandy marl]	8	3		
	Stone bind	5	4		
	Dark blue and black bind	26	11		
	Clunchy stone bind	19	5		
	Coal	2	9	1,306	6
	Stone clunch [grey sandstone] ...	4	0		
	Clunchy grey bind	13	2		
	Coal 2 ft. 11 in., clunch parting 10 in.	3	9	1,327	5
	Clunch	3	11		
	Strong grey bind	53	8		
	Black bind	14	4		
	Dark blue bind [*Anthracomya phillipsi*]	14	11		
	Black bind	0	2		
	Coal, High Hazles...	3	9	1,418	2
	Clunch	1	3		
	Stone clunch and stone bind [sandstone]	14	11		
	Blue bind with ironstone bands ...	14	2		
	Dark bind	7	7		
	Coal	0	8	1,456	9
	Clunch	3	9		
	Dark blue bind	15	1		
	Coal	0	5	1,476	0
	Clunch	5	5		
	Black bind with coal streaks... ...	0	3		
	Stone clunch and stone bind... ...	5	3		
	Strong grey bind	14	0		
	Black bind	2	4		

Mansfield Colliery—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Dark blue bind with ironstone ...	5	1		
	Grey bind	2	10		
	Stone bind and rock bands	3	8		
	Blue bind	10	5		
	Black bind, batty coal and clunch ...	1	7		
	Clunch	2	1		
	Blue and stone bind mixed	6	10		
	Stone bind and grey rock	7	5		
	Strong grey bind	9	10		
	Blue bind	9	6		
	Black bind	1	4		
	Coal	1	0	1,564	10
	Clunch	5	7		
	Blue bind and black bind	0	9		
	Clunch	1	9		
	Coal	0	8	1,573	7
	Stone clunch	1	3		
	Strong grey bind	10	10		
	Blue bind	2	0		
	Stone bind	35	7		
	Black bind	0	11		
	Dark clunch	0	6½		
	Coal, Coombe...	1	2½	1,625	11
	Clunch	0	3½		
	Coal, Top Hard	5	2	1,631	4½
	Stone clunch	4	1½		
	Grey rock	19	4		
	Grey clunch and bind...	32	10		
	Coal, Dunsil	2	2	1,689	10

No. 16.

Owthorpe Boring.

1 in. Map (N.S.) 142 ; 6 in. Map, Notts., 47 N. 10.

Abridged from fuller account given in the "Geology of Newark and Nottingham." *Mem. Geol. Surv.*, 1908, pp. 106–8, and "Geology of S.W. part of Lincolnshire." *Mem. Geol. Surv.*, 1885, p. 150–2.

Height above O.D. 200 ft.

			Thickness. Ft.	In.	Depth. Ft.	In.
Lias ...		Clays and limestones	12	6	12	6
Trias ...	Lower Mottled Sandstone and Bunter Pebble Beds.	Rhætic: Blue shale	1	3		
		Rhætic: Grey marl...	19	3		
		Rhætic: Black shale	14	0	47	0
		Waterstones and Keuper Marl.: Blue stone and clay [Tea-green Marl]	19	0		
		Waterstones and Keuper Marl.: Red and grey marl, partings of rock, gypsum	608	0	674	0
		Waterstones and Keuper Marl.: Hard red and grey rock ...	69	0		
		Waterstones and Keuper Marl.: Red and grey rock with marl	30	0		
		Waterstones and Keuper Marl.: Bluish grey rock	22	6	795	6
		Red and grey sandstone with pebbles	146	6		
		Red clay	2	0		
		Red and grey sandstone with pebbles	56	0		
		Red and grey sandstone ...	50	0		
		Conglomerate sandstone	19	0	1,069	0

Owthorpe Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures	Red marl with iron ore	14	0		
	Dark purple marly shale	15	0		
	Dark blue shale	18	3		
	Coal	0	3	1,116	6
	Blue shale with ironstone	29	0		
	Coal	2	4	1,147	10
	Shales (chiefly), sandstones, ironstones	152	2		
	Coal	2	3	1,302	3
	Blue shale, ironstone, thin coals	100	0		
	Coal	1	10	1,404	1
	Fireclay, shale (*Carbonicola aquilina*), ironstone	39	6		
	Coal	1	6	1,445	1
	Fireclay	3	0		
	Coal	1	4	1,449	5
	Shale with ironstone	51	9		
	Coal	3	3	1,504	5
	Fireclay, sandstone, shale	31	4		
	Coal	0	5	1,536	2
	Blue shale with ironstone	7	10		
	Coal	0	8	1,544	8
	Fireclay, sandy shales	27	10		
	Blue shale with ironstone (Marine Bed	38	8	1,611	2
	Coal	0	6	1,611	8
	Sandy shale, ironstone	8	1		
	Coal	0	9	1,620	6
	Grey and blue shale, ironstone	56	11		
	Coal	1	3	1,678	8
	Fireclay and sandy shale	47	10		
	Coal	3	5	1,729	11
	Fireclays and ironstones	24	2		
	Coal	2	9	1,756	10
	Fireclay	0	5		
	Coal	0	7	1,757	10
	Cannel	1	0	1,758	10
	Black shale and fireclay	4	11		
	Coal	1	2	1,764	11
	Shales, fireclays, sandstones and ironstones	49	8		
	Coal	0	10	1,815	5
	Black shale	0	7		
	Coal	3	6	1,819	6
	Fireclays and ironstone	15	4		
	Coal	1	6	1,836	4
	Grey shale with sandstone	29	1		
	Coal	2	9	1,868	2
	Shale, fireclay and ironstone	8	2		
	Coal	1	5	1,877	9
	Shales and ironstone	41	2		
	Coal	2	8	1,921	7
	Shale, ironstone and sandstone	22	2		
	Bluish grey rock with spar joints (Igneous rock)	39	1	1,982	10
	Shale, sandstone and ironstone	24	10		
	Coal	4	8	2,012	4
	Fireclay, shales and sandstones	19	11	2,032	3

No. 17.

Oxton Boring.

1 in. Map. (N.S.) 126 ; 6 in. Map, Notts., 33 N.E.

Abridged from account given in "Geology of Newark and Nottingham." *Mem. Geol. Surv.*, 1908, pp. 109–11.

Height above O.D. 260 ft.

			Thickness. Ft.	In.	Depth. Ft.	In.
Trias ...	Bunter.	Sand and gravel	12	0		
		Sandstone and pebbly sandstone	199	0		
		Soft red sandstone	152	0		
		Grey and red sandstone ...	11	6	374	6
Permian ...	Marl Slates, &c.	Red marl	9	2		
		Sandy dolomitic limestone ...	28	10		
		Limestone	15	6		
		Hard blue shale	85	6		
		Breccia	2	6	516	0
	Etruria Marl.	Red and mottled marls ...	99	0	615	0
		Variegated marl and grey sandstone	60	0		
		Mottled marl	68	0	743	0
Coal Measures.		Blue shale and marl	70	0		
		Fireclay, with fragments of coal ...	5	0		
		Shale, fireclay, sandstone	142	0		
		Black clunch (? with coal)	1	0	961	0
		Grey shale, sandstone and thin coal...	115	0		
		Coal	1	0	1,077	0
		Fireclay, sandstone	33	0		
		Coal	0	2	1,110	2
		Fireclay, sandy shale, shale, sandstone	282	10		
		Coal	2	0	1,395	0
		Fireclay, shale, sandstone	44	6		
		Coal	2	0	1,439	8
		Fireclay, shale	33	10		
		Grey shale	23	6	1,497	0
		Blue argillaceous limestone (goniatites, &c.), Mansfield Marine Bed...	1	6	1,498	6
		Dark grey shale	1	6		
		Coal	0	4	1,500	4
		Fireclay	0	8		
		Shale with ironstone	52	6		
		Hard grey sandstone	46	6		
		Shale	123	0		
		Coal	0	3	1,723	3
		Bind and strong bind...	149	9		
		Coal	0	2	1,873	2
		Sandy shale, shale	78	10		
		Black shale and thin coal	5	3		
		Fireclay or shale	8	9		
		Grey sandstone	2	0		
		Dark grey shale, nodules	16	0		
		Strong sandy bind	25	0		
		Blue bind with nodules	17	3		
		Coal, Top Hard	4	1	2,030	4
		Fireclay	1	6		
		Sandstone and sandy bind	18	2	2,050	0

No. 18.

Ruddington Boring.

1 in. Map (N.S.) 142 ; 6 in Map, Notts., 46 N.W.

Abridged from account given in "Geology of Newark and Nottingham." *Mem. Geol. Surv.*, 1908, pp. 112–3.

Height above O.D. 100 ft.

			Thickness. Ft.	In.	Depth. Ft.	In.
		Soil	1	0		
		Clay sand, and gravel	6	0	7	0
Trias ...	Keuper Marl.	Red and blue marl with thin beds of soft sandstone or limestone and gypsum veins	386	0	393	0
	Keuper Water-stones.	Red and grey sandstones, marls and marly sandstones	70	9		
		Conglomerate	3	0	466	9
	Bunter Pebble Beds.	Red and grey pebbly sandstones with partings of red and blue marl	218	7		
		Coarse red sandstones with grey veins...	2	0	687	4
Coal Measures.	Lower Coal Measures.	Red and grey sandstones with beds of marl	11	8		
		Red and grey sandstones with thin beds of blue shale ...	58	9	757	9
		Shales, fireclays and ironstones...	184	4		
		Coal, Naughton	2	5	944	6
		Clay with ironstone and shale ...	21	6		
		Coal	1	0	967	0
		Fireclay, shale, and shaly sandstone	49	8		
		Blue shale with ironstone (Marine Bed)	52	9		
		Coal, Alton	3	4	1,072	9
		Fireclay and shales	32	1		
		Coal	0	7	1,105	5
		Shale with coal partings, sandy shale and shaly sandstone ...	25	7	1,131	0
Millstone Grit Series		Grey sandstone, in places pebbly and shaly [Rough Rock]	164	8	1,295	8
		Blue shale with ironstone	67	1		
		Blue shale [*Lingula squamiformis*]...	7	2		
		Sandstone, shale and ironstone bands	50	7		
		Coal	0	3	1,420	9
		Fireclay, sandy	8	0		
		Grey sandstone ard stone-bind ...	110	3		
		Blue shale, shaly sandstone, and thin veins of coal...	218	3		
		Coal	1	4	1,758	7
		Fireclay	0	8		
		Coal	1	4	1,760	7
		Fireclay	0	4		
		Blue shaly and grey and reddish sandstone [Kinderscout Grit] ...	109	5	1,870	4

No. 19.

Selby Boring.

1 in. Map (N.S.) 79 ; 6 in. Map, Yorks., 236 N.E.

Communicated by Mr. H. St. John Durnford.

Height above O.D. 16.

[Abridged.]

			Thickness. Ft.	Thickness. In.	Depth. Ft.	Depth. In.
		Soft yellow clay	28	6		
		Drift sand...	1	6		
		Strong clay	24	0		
		Drift sand...	16	0	70	0
Trias ...	Bunter Sandstone.	Red compact sand	254	0		
		Red sandstone with marl partings	87	0		
		Red sandstone with marl patches	100	0		
		Red sandstone and marl ...	149	0	660	0
Permian ...	Upper Marls.	Red marl with gypsum streaks	64	0		
		Anhydrite	18	0		
		Red marl and gypsum bands	13	6		
		Limestone and gypsum ...	6	6		
		Marl and gypsum	7	0	769	0
	Upper Limestone.	Limestone and gypsum ...	8	0		
		Limestone	89	0		
		Limestone with shale bands	12	0	878	0
	Middle Marls.	Red marl with gypsum and limestone bands	51	0		
		Mottled marl and limestone with soft friable partings...	23	0	952	0
	Basal Beds and Lower Limestone.	Limestone	12	6		
		Limestone with anhydrite ...	19	6		
		Limestone	16	6		
		Limestone with gypsum ...	70	0		
		Limestone	193	6		
		Blue shale [*Lingula credneri*]	3	0		
		Soft sandstone	17	0	1,284	0
Coal Measures.		Reddish sandstone	44	0		
		Mottled marl	29	0		
		Dark shale and hard bands	35	0		
		Shale and sandstone	28	0		
		Grey shale and sandstone	41	9		
		Coal streak	0	3		
		Strong grey shales and nodules ...	40	0		
		Grey shale	13	6		
		Dark shale and iron bands	22	6		
		Coal	1	6	1,539	6
		Dark shale and iron bands	18	6		
		Coal, 1 ft. 6 in. ; bass, 2 in. ; coal, 2 ft. 8 in. ; fireclay, 2 in. ; coal, 2 in.	4	8	1,562	8
		Warrant	0	3		
		Stone bind	0	2		
		Dark warrant	0	6		
		Fireclay	3	0		
		Strong blue shale	18	6		
		Coal	2	0	1,587	1
		Dark shale	0	6		
		Laminated sandstone	10	0		
		Blue shale	35	6		

Selby Boring—*continued.*

		Thickness.		Depth.	
		Ft.	In.	Ft.	In
Coal Measures —*cont.*	Coal	2	3	1,635	4
	Blue shale	30	9		
	Grey sandstone	35	0		
	Blue sandy shale, very strong	38	0		
	Blue shales and nodules	39	0		
	Grey sandstone	1	0		
	Blue shale	2	10		
	Coal	0	10	1,782	9
	Fireclay	0	4		
	Blue shale and nodules	33	0		
	Jointy black shale	2	0		
	Strong grey shale	10	6		
	Coal	2	0	1,830	7
	Fireclay	4	0		
	Black shales and nodules	7	6		
	Strong grey sandy shale	19	0		
	Grey shale	58	9		
	Blue shale	27	6		
	Light sandy shale	34	8		
	Jointy dark shale and nodules	10	0		
	Fireclay (rotten)	5	0		
	Jointy, dark shale	5	0		
	Fireclay (rotten)	3	0		
	Jointy, dark, and light-grey shale	29	0		
	Coal	1	0	2,035	1 [1]
	Strong blue shale	14	0		
	Strong blue sandy shale	28	0		
	Grey sandstone with coal streaks	2	0		
	Dark jointy shale and ironstone band	6	3		
	Strong grey shale	20	3		
	Fireclay (rotten)	4	0	2,109	7
	Jointy shale	14	0		
	Jointy dark shale with coal veins	19	0		
	Grey sandstone	25	6		
	Grey shale, jointy	11	0		
	Sandstone	16	6		
	Grey shale with sandstone partings	14	0		
	Black shale and nodules, jointy	13	0		
	Jointy dark shale	20	0		
	Jointy dark shale with nodnles	14	0		
	Coal	2	0	2,258	7
	Strong grey shale and nodules	3	0		
	Faulty coal and warrant	8	6	2,270	1
	Underclay	1	0		
	Sandstone, laminated	12	0		
	Grey shale and sandy shale	7	0		
	Dark shale and nodules, jointy	6	0		
	Warrant and sandstone	8	6		
	Grey and blue sandy shale with nodules	15	6		
	Grey sandstone, laminated	8	0		
	Grey shale	2	3		
	Black shale	4	3		
	Grey shale and nodules	32	0		
	Grey sandstone	9	6		
	Grey and dark shales, with some nodules	68	6		
	Fireclay	15	0		
	Grey sandy shale	4	6		

[1] Given as 2,034 ft. 0 in. in the original.

Selby Boring—*continued.*

		Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Friable warrant	3	6		
	Grey shales and nodules	15	6		
	Sandstone, laminated	22	3		
	Warrant and fireclay, with small coal	4	6		
	Sandstone, laminated	19	0		
	Blue shale and ironstone bands ...	15	0		
	Fireclay and nodules	7	3		
	Grey sandstone	3	9		
	Dark shale, nodules, and coal streaks	4	0		
	Sandstone, laminated	7	3		
	Blue sandy shale	7	9		
	Black shale	1	3		
	Coal	0	4	2,575	5
	Fireclay	1	2		
	Sandstone	15	0		
	Black shale with coal streaks ...	4	9		
	Grey sandy shale	30	6		
	Fireclay	3	0		
	Sandstone, laminated in part ...	82	0		
	Grey shale and sandy shale	61	0		
	Sandstone, strong	38	10		
	Coal	0	4		
	Fireclay (rotten)	5	4		
	Coal	2	0	2,818	7
	Black shale	2	0		
	Grey shales and nodules, jointy ...	32	6		
	Soft friable warrant	7	0		
	Grey shale with nodules	6	6		
	Soft friable warrant	4	6		
	Sandy shale	42	6		
	Grey shale and ironstone	25	3		
	Grey sandstone and sandy shale ...	12	5		
	Black shale	0	4		
	Grey sandy shale	58	0	3,009	7

No. 20.

Spinney Boring.

1 in. Map (N.S.) 126 ; 6 in. Map, Notts., 42 S.W.

Abridged from MS. in Survey Office.

Height above O.D. 90 ft.

			Thickness. Ft.	In.	Depth. Ft.	In.
Trias ...	Keuper Marl.	Red marl with grey bands ...	48	2		
		Grey rock and thin beds of gypsum	6	5		
		Red marl and hard grey rock ...	7	9		
		Marl and gypsum bands ...	1	6		
		Hard and soft grey rock ...	4	1		
		Hard rock and gypsum	1	6		
		Red marl, bands of grey rock ...	20	1		
		Red marl and gypsum	14	1		
		Red and grey marl	8	11		
		Hard brown and grey rock with gypsum	30	1	142	7

Spinney Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In
Trias—*cont.*	Lower Mottled Sandstone and Bunter Pebble Beds.	Keuper Waterstones.				
		Red and grey sandstone ...	99	3		
		Red marl	10	5		
		Brown and grey sandstone	22	9		
		Light grey rock, pebbly ...	2	10	277	10
		Red and grey sand rock ...	11	3		
		Conglomerate	4	5		
		Whitish freestone	0	6		
		Light grey conglomerate ...	1	1		
		Grey sand rock	65	7		
		Hard conglomerate ...	5	1		
		Grey sandstone	12	0		
		Soft grey conglomerate ...	18	2		
		Grey and brown sand rock	116	10	512	9
Coal Measures.		Red, grey and purple marl	6	2		
		Clunch	12	0		
		Bind with ironstone	21	5	552	4
		Coal	0	8½		
		Clay	0	0½		
		Coal	0	5		
		Clunch	0	7		
		Coal, hard	1	0		
		Coal	4	6¾	559	7¾
		Clunch	1	5¼		
		Bind	1	2		
		Shale with ironstone	4	3	566	6

No. 21.

Thorne Boring.

1 in. Map (N.S.) 79 ; 6 in Map, Yorks., 266 N.W.

Communicated by Messrs. Pease Partners.

Height above O.D. 20 ft.

(Slightly abridged.)

			Thickness. Ft.	In.	Depth. Ft.	In.
		Soil	2	0		
		Clay (warp)	25	0		
Glacial ...		Sand and gravel	33	0	60	0
Trias ...	Bunter and ? Keuper Sandstones (122 ft.).	Soft red sandstone	120	0		
		Red and grey sandstone ...	2	0		
		Red standstone and nodules of red marl	100	0		
		Red sandstone...	40	0		
		Red and grey sandstone with marl	60	0		
		Red sandstone with marl ...	124	0		
		Red sandstone...	367	0		
		Red sandstone with marl ...	42	6		
		Grey sandstone	1	0	916	6
Permian ...	Upper Marls.	Red marl	33	6		
		Red marl and gypsum veins ...	15	0		
		Grey sandstone and gypsum ...	1	0		
		Red marl and gypsum	17	0		
		Red and grey rock	20	6		
		Red marl and gypsum	44	0	1,047	6

Thorne Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Permian —*cont.*	Upper Limestone.	Limestone and gypsum ...	1	0		
		Ironstone	0	6		
		Gypsum	0	6		
		Ironstone	0	8		
		Grey limestone	15	4		
		Light blue shale	1	0		
		Grey limestone	73	0	1,139	6
	Middle Marls.	Light blue shale and gypsum ...	20	0		
		Red marl	40	0		
		Red and blue marl and limestone	11	0		
		Red and blue marl	19	6		
		Red gypsum	0	6		
		Brown and blue marl	9	0		
		Grey anhydrite	4	6		
		Grey limestone	2	6		
		Grey and brown marl	7	0		
		Brown limestone	4	0		
		Brown and grey marl	7	0	1,264	6
	Lower Limestone and Basal beds.	Limestone	261	0		
		Grey shale and limestone veins	4	0		
		Grey shale	8	0		
		Dark grey sandstone ...	1	0	1,538	6
Coal Measures.		Mottled marl	3	6		
		Grey sandstone	12	6		
		Mottled marl	3	0		
		Blue shale	4	0		
		Coal	0	10	1,562	4
		Fireclay	16	6		
		Grey shale and sandy shale	11	8		
		Coal, shaly	0	2	1,590	8
		Grey shale and ironstone balls ...	18	4		
		Mottled marl	3	6		
		Dark shale and ironstone bands ...	7	6		
		Grey sandstone	8	0		
		Dark grey shale and ironstone balls	25	4		
		Coal, shaly	0	8	1,654	0
		Dark grey shale and ironstone balls	13	6		
		Grey sandstone	7	6		
		Grey shale and ironstone nodules ...	27	9		
		Fireclay	3	0		
		Grey sandy shale	11	6		
		Grey shale and ironstone nodules ...	40	0		
		Sandy shale and sandstone	15	6		
		Grey shale and ironstone nodules ...	11	6		
		Black shale	0	6		
		Coal, Shafton	1	9	1,786	6
		Fireclay	1	9		
		Grey shale	16	9		
		Coal	0	3	1,805	3
		Black shale	0	9		
		Fireclay	5	0		
		Grey and black shales with ironstone nodules	56	0		
		Fireclay	1	9		
		Sandy shale and sandstone	197	6		
		Coal	0	1	2,066	4
		Fireclay	3	0		
		Grey shale	15	8		
		Fireclay	3	0		
		Sbale, sandy shale and sandstone ...	79	6		

Thorne Boring—*continued.*

		Thickness.		Depth.	
		Ft.	In.	Ft.	In.
	Grey shale and ironstone balls ... ... (Mansfield Marine Bed.)	5	0		
	Black shale ... ... (Mansfield Marine Bed.)	10	0	2,182	6
	Fireclay	9	0		
	Shaly sandstone and shale	19	0		
	Black shale	2	0		
	Black shale and coal streaks	1	6		
	Grey shale	17	0		
	Fireclay	5	0		
	Grey shale	39	0		
	Grey sandstone with coal streaks ...	30	0		
	Sandy shale and black shale mixed...	34	0		
	Fireclay	2	0		
	Black shale	1	0		
	Coal	0	6	2,342	6
	Fireclay	3	0		
	Grey sandy shale, shale, and sandstone	100	0		
	Black shale	1	0		
	Fireclay	1	6		
	Sandy shale and sandstone	10	0		
	Grey shale and ironstone	25	0		
	Shale and sandy shale, some ironstone	58	6		
	Coal	1	0	2,542	6
	Fireclay	7	6		
	Grey shale and ironstone bands and balls	29	0		
	Black shale	1	0		
	Grey shale	5	0		
	Black shale	1	0		
	Hard fireclay	2	0		
Coal Measures —*cont.*	Grey shale and ironstone balls ...	13	6		
	Fireclay	0	6		
	Sandy shale and shale	25	6		
	Black shale	2	0		
	Coal	0	4	2,629	10
	Fireclay and ironstone balls	6	2		
	Grey and black shale	3	6		
	Coal ?	—		2,639	6
	Fireclay	6	2		
	Ironstone band	0	4		
	Grey sandstone and sandy shale ...	28	0		
	Coal	0	8	2,674	8
	Fireclay	0	4		
	Black shale and ironstone balls ...	2	0		
	Black shale with traces of coal ...	3	0		
	Black shale	4	6		
	Grey and dark shale with ironstone	10	6		
	Blue shale	0	6		
	Fireclay	3	0		
	Grey shale and ironstone	6	6		
	Sandy shale	35	6		
	Ironstone band	0	6		
	Blue shale and ironstone band ...	4	0		
	Dark shale	2	0		
	Clunch	1	0		
	Coal, Barnsley	8	11	2,756	11
	Fireclay	3	1		
	Grey shale and ironstone	5	6		
	Sandstone and sandy shale	14	6		
	Blue shale	5	6		
	Coal, Dunsil ?	4	0	2,789	6
	Fireclay	5	0		
	Stone bind	6	0	2,800	6

No. 22.

Thurgarton Boring.

1 in. Map (N.S.) 126 ; 6 in. Map, Notts., 34 S.E.

Abridged from account given in "Geology of Newark and Nottingham," *Mem. Geol. Surv.*, 1908, pp. 113–16.

Height above O.D. 57.

			Thickness. Ft.	Thickness. In.	Depth Ft.	Depth In.
Trias ...	Keuper Marl.	Blue sandy clay	4	6		
		Sand and gravel	16	6	21	0
		Blue and red clay	5	6		
		Strong marl and gypsum ...	6	6		
		Blue and red marl with gypsum	51	1		
		Red and blue marls, hard grey sandstone	9	3		
		Red marl and gypsum	20	5	113	9
	Keuper Waterstones.	Red sandy marl, gypsum, and bands of grey sandstone ...	98	8		
		Red sandy marl and marly sandstone	44	6		
		Coarse grey sandstone ...	0	8		
		Red and blue sandy marl ...	3	6		
		Grey pebbly sandstone with spar	2	8	263	9
	Lower Mottled Sandstone and Bunter Pebble Beds.	Grey pebbly sandstone ...	3	10		
		Red and grey sandstone ...	32	8		
		Reddish grey pebbly sandstones	288	3		
		Red and grey sandstone, sandy marl	86	6		
		Red sandstone, pebbly sandstone	34	2		
		Red brecciated conglomerate	7	0	716	2
		Red marly sandstone, red marl	41	0	757	2
Permian ...	Marl Slates, &c.	Red and blue shale with sandstone partings	48	4		
		Gypsum	0	6		
		Grey sandstone [? Magnesian Limestone]	20	0		
		Blue shale, breccia at base ...	24	6	850	6
Coal Measures.	Keele Group.	Red and grey sandstone... ...	24	6		
		Red and purple marl	14	6		
		Purple, reddish and grey sandstone	69	6		
		Reddish grey sandstones [*Pecopteris arborescens*]	25	6		
		Red and mottled marl	51	6		
		Black shale and ironstone ...	2	0	1,038	0
	Newcastle Group.	Grey sandstone	5	6		
		Blue shale	6	0		
		Coal	0	3	1,049	9
		Blue shale and grey sandstone	7	3		
		Blue shale with limestone nodules	34	0	1,091	0
	Etruria Marl Group.	Red and blue shale	38	6		
		Deep red marl	20	8		
		Green conglomerate, Espley rock	1	0	1,151	2
		Red marl	2	6		
		Green conglomerate, Espley rock	0	6	1,154	2
		Strong red marl	10	7		

Thurgarton Boring—*continued.*

			Thickness. Ft.	In.	Depth. Ft.	In.
Coal Measures —*cont.*	Etruria Marl Group —*cont.*	Strong blue sandstone, Espley rock	9	8	1,174	5
		Red and mottled marl ...	—			
		Blue conglomerate, Espley rock	8	6	1,224	0
		Red mottled and variegated marl	42	0		
		Grey marly sandstone ...	31	9		
		Grey sandstone, Espley rock...	3	0	1,300	9
		Mottled marl, grey sandstone, sandy shale	73	3	1,374	0
		Blue shale	16	10		
		Coal, soft	0	10	1,391	8
		Fireclay, shale	21	8		
		Coal, joint	0	2	1,413	6
		Shale, ironstones, sandy shales ...	171	6		
		Coal and batt	0	3	1,585	3
		Fireclay, shale	29	0		
		Coal	0	6	1,614	9
		Fireclay, shale, ironstone[1]	102	4		
		Grey sandstone	16	10		
		Shale, fireclay, ironstone, thin sandstones	248	4		
		Grey sandstone	17	9		
		Fireclay, sandy shale	45	6		
		Grey sandstone	11	0		
		Blue shale, ironstone	30	6		
		Grey sandstone	64	0		
		Blue shale, ironstone, fireclay ...	86	6	2,237	6

[1] Marine shells at 1,672 ft.

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MIDLAND DISTRICT—*cont.*

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